NBER WORKING PAPERS SERIES

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Working Paper No. 3741

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
June 1991

This paper is part of NBER's research program in Labor Studies. Any opinions expressed are those of the authors and not those of the National Bureau of Economic Research.

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ABSTRACT

Projections of forthcoming shortages of Ph.D.s and thus new faculty for the academic sector, abound. Among the policies proposed to prevent such shortages is increased federal support for graduate students. Lost in the policy debate, however, has been concern for the possibility that increased federal support might induce academic institutions to redirect their own internal resources in a way that at least partially frustrates the intent of the policy change.

Our paper presents an analysis of this issue using institutionally-based data for science and engineering fields. We find that doctorate-producing universities do respond to changes in external support for graduate students by altering the number of students they support on institutional funds. While adjustments to changes in external support levels appear to be quite rapid, the magnitude of these responses are quite small. On average, an increase of 100 in the number of students supported by external funds is estimated to reduce the number supported on institutional funds by 22 to 23. We also find that the magnitude of the response varies across fields, that within the science and engineering fields there is some fungibility of external support across fields, and that changes in external support influence the distribution of internal support by type of support (fellowship, research assistantship, and teaching assistantship).

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How Would Universities Respond to Increased Federal Support for Graduate Students

by

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I. Introduction

Projections of forthcoming shortages of Ph.D.s, and thus new faculty for the academic sector, abound.[1] The demand for new faculty is projected to increase due to increased retirements from an aging professoriate and projected increases in college enrollments. On the supply side, while the number of Ph.D.s granted by U.S. universities has been roughly constant in recent years, increasingly nonacademic job opportunities are available to Ph.D.s. Ph.D. recipients are also increasingly non-American citizen whose observed probabilities of obtaining employment in the United States are low.[2] Integration of supply and demand forces leads to the projections of forthcoming shortage; one major book projected at least a 43 percent underproduction of new doctorates in the arts and sciences as a whole during the 1997-2002 period.[3]

American college graduates are much less likely to receive doctorates today than they were 20 years ago. While the ratio of doctorates granted by American universities to bachelors degrees granted by American colleges and universities six years earlier was .064 in 1970-71, it fell to .035 in 1978-79 and has remained roughly constant at the lower level since then.[4] Numerous factors probably contribute to this decline in the propensity of American college graduates to receive doctorates, however one important factor may well be the increase in the length of time necessary for doctorate students to complete their programs.

The median registered time to degree for new Ph.D.s granted in the United States in 1968 was 5.5 years. By 1988, this figure had risen to 6.9 years. The increase has been even more dramatic in some fields; for example, in the social sciences median registered time to degree rose from 5.1 to 7.4 years and in the humanities from 5.5 to 8.5 years during the same period.[5]

Among the policies urged to prevent future Ph.D. shortages is increased federal support for graduate students. Such a policy would reduce the private costs of doctoral study and thus hopefully should increase the number of college graduates willing to undertake graduate study. To the extent that financial support reduces the time students need to complete degrees and increases their probability of completing doctoral programs, the future supply of Ph.D.s should further increase. While conceptually these roles of financial support on the supply of doctorates are clear, empirical evidence on the effects of financial support on doctoral production actually is quite scanty.[6]

Lost in the policy debate, however, has been any concern for the possibility that changes in federal, or other external to the institution, support for graduate education may simply induce an academic institution to redirect its own financial resources in a way that at least partially frustrates the intent of such a policy. For example, increased federal support for graduate students in the sciences may lead an institution to cut back somewhat on (or not increase as rapidly as it had planned) its own internal support for graduate students in the sciences and use the funds saved either to support graduate students in other disciplines or for other purposes (e.g., nongraduate student expenditures or moderating planned tuition increase). Conversely, faced with cutbacks in federal or other external support, institutions may react by attempting to partially offset the cutbacks by increasing their own internal support for graduate education.

To the extent that changes in federal or other external financial support for graduate education lead institutions to redirect and/or reduce their own expenditures, changes in the field composition and total number of doctorates that are produced may be different than what policymakers intended. The issue being raised here is very similar to one confronted by policymakers in the 1970s and early 1980s when concern was expressed that the net job creation effects of public sector employment programs, programs in which the federal government gave state and local governments funds to increase their employment levels, were considerably less than the number of positions funded. Empirical studies of what became known as the displacement effect, or fiscal substitution effect, of public sector employment programs did indeed find that, on average, an increase in PSE program positions typically led to a smaller increase in public sector employment levels.[7]

To fully analyze the likely effects of an increase in federal support for graduate students, an analysis of the extent to which the federal funds would displace institutional funds is required. Such an analysis is undertaken in this paper, using institutionally-based data for science (including social science) and engineering fields. Unfortunately, data do not exist that would permit similar analyses for the humanities and for professional fields other than engineering.

We begin in the next section with a discussion of the aggregate time-series evidence on how support for graduate students in science and engineering has changed. While this evidence suggests that federal policies may influence institutional support levels, causation can not be inferred from these aggregate data.

In section III, we present institutionally-based econometric analyses of the determinants of the number of full-time graduate students in science and engineering fields that receive institutional support. The analyses are extended in section IV to field-specific data and attempts made to ascertain if increased external support to one field may influence internal support allocations to other fields. Section V further extends the analyses and addresses how different types of external support (e.g., fellowship and traineeships, research assistantships, teaching assistantships) influence the distribution of types of internal support. The brief concluding section summarizes our findings and lays out an agenda for future research.

II. Aggregate Time-Series Evidence

Table 1 presents evidence for the 1966 to 1988 period on the number of full-time science and engineering graduate students (FTSEG) in doctorate-granting institutions whose major source of support came from the federal government each year. Psychology and the social sciences are included among the sciences for the purposes of this table and those that follow.

The data in column (A) come from a National Science Foundation survey, the scope of which changed over time. For example, in 1972 the survey was expanded to include graduate students in doctorate-granting institutions in departments that granted only masters degrees, while in 1973 it was expanded to include graduate students in medical and clinical sciences. Response rates to this survey varied over time. The data in column (B) come from a separate, but similar National Science Foundation survey. Response rates to this survey also varied over time. The two surveys overlapped during the 1974 to 1977 period and for the last three years in which they overlapped, they yielded virtually identical aggregate numbers.

During the 1966 to 1988 period, the number of FTSEG students at doctorate-granting institutions whose major source of support came from the federal government fluctuated in the 43,000 to almost 55,000 range. In recent years, however, there has been a clear upward trend. The number of students on federal support rose steadily between 1982 and 1988 and the 1988 level of 54,852 was over 16 percent higher than the 1982 level of 47,206.

As the second panel indicates, however, the total number of FTSEG students enrolled in doctorate-granting institutions increased throughout the period, rising (using the consistent series B) from about 195,500 in 1975 to almost 268,400 in 1988. As a result, the share of FTSEG students in doctorate-granting institutions whose major source of financial support came from the federal government, fell from almost 38 percent in 1966 to slightly over 19 percent in 1984. Between 1984 and 1988, as the number of FTSEG students with federal support increased, the share with federal support increased slightly to 20.4 percent. However, this is still well below the shares experienced in the late 1960s and early 1970s.

Table 2 repeats the percentage of FTSEG students with federal support data and adds in information on the percentages whose major source of support were "institutional" funds, "other outside" funds, and "self-support". In these NSF data, "institutional funds" are defined to include funds from state governments administered by the institutions, "other outside" funds include funds derived from foundation and corporation, as well as from foreign sources, while "self-support" includes loans, family support, and earnings from outside the university.

Quite strikingly, the fall from 1974 to 1988 in the percentage of FTSEG students whose major source of support was the federal government from 24.6 to 20.4 was substantially offset by the increase in the percentage of FTSEG students who received institutional support.[8] As noted above, while this suggests that changes in federal support for graduate students may induce institutions to alter their own support levels, causation should not be inferred from these aggregate time-series data.

As the distribution of FTSEG students by major source of support has changed, so has the distribution of students receiving support by type of support. Table 3 presents information for 1968, 1974 and 1988, in total and for selected major fields, on the percentages of FTSEG in doctorate-granting institutions by type of support. The fellowship category includes fellowships and research traineeships, the RA category represents research assistantships, the TA category represents teaching assistantships and the other category includes tuition waivers and self-support.[9]

In the aggregate, a steep decline between 1968 and 1988 in the percentage of students supported by fellowships has been offset by a small increase in the percentage supported by research assistantships and a large increase in the percentage who are on other types of support. Focusing on the 1984-88 period, the almost 6 percentage point decline in the percentage of students supported by fellowships was offset by a slightly larger increase in the percentage of students supported by research assistantships. However, patterns of change vary widely across fields. For example, during the 1974 to 1988 period, the decline in the percentage of students in the social sciences supported by fellowships was offset primarily by an increase in the percentage supported by teaching assistantships.

Changes in external support of a particular type may well affect more than one type of institutional support. For example, an increase in the number of federally funded research assistantships received by an institution might prompt the institution to reduce the number of research assistants it awards out of institutional funds but, in an effort to attract top students, to increase the number of fellowships it awards out of institutional funds. We provide estimates of such substitution across types of support in section V.

Finally, it is worth noting that Tables 1, 2, and 3 all refer to full-time students. As the data presented in Table 4 show, in the aggregate the percentage of science and engineering graduate students at doctorate-granting institutions who are enrolled part-time has risen over the 1974-1988 period. No such increase occurred in engineering, where the proportion of full-time students on fellowships, research assistantships and teaching assistantships was higher in 1974 than it was in 1988 (Table 3). However, the increase in the proportion of part-time graduate students in psychology and the social sciences started as far back as 1968. Although we do not pursue the topic below, analyses of how changes in federal and other external support levels influence the proportion of graduate students who are enrolled part-time, is also of obvious interest.

III. Institutionally Based Analyses

Consider the following simple equation that seeks to explain the number of FTSEG students in institution j in academic year t supported by institutional funds (I_{jt}).

$$(1) \quad I_{jt} = a_0 + a_1X_{jt} + a_2F_{jt} + a_3A_{jt} + v_{jt} + \epsilon_{jt}$$

Here X_{jt} is the number of undergraduate students that the institution expects to be enrolled in science and engineering courses during the academic year, F_{jt} is the number of science and engineering faculty employed by the institution in the academic year, A_{jt} is the number of FTSEG students in the institution supported by federal government and other external funds in the academic year, V_{jt} is an institution-specific error term, and ϵ_{jt} is a random error term.

Presumably an increase in undergraduate student enrollments will increase the institution's demand for teaching assistants, so a_1 is expected to be positive. While an increase in science and engineering faculty size will similarly increase the institution's demand for graduate research assistants, holding undergraduate enrollments constant, it might decrease the institution's demand for teaching assistants. Thus, the sign of a_2 is a priori indeterminate.

The key variable in the model is the number of FTSEG students supported on external funds. At one extreme, if the number of students the institution supports is independent of the number that federal government and other external sources support, no displacement takes place and a_3 will be zero. In contrast, if the institution reduces the number of students it supports by exactly the number that the federal government and other external sources support, displacement will be complete and a_3 will equal minus one. Values of a_3 between zero and minus one indicate partial substitution of external for institution funds.

In theory, equation (1) can be estimated using a single year's data for a cross-section of doctorate-producing universities. However, the institution-specific error term presents a problem. Surely there are many other variables besides an institution's undergraduate enrollments and its faculty size that should affect its willingness to finance graduate students out of its own internal funds. Omission of these variables, which are captured by the institution-specific error term, may lead to biased coefficient estimates.

For example, suppose institutions that place a high value on graduate education and research simultaneously support above average (given their size) numbers of graduate students <u>and</u> hire first-rate faculty, who succeed in attracting above-average levels of support for graduate students from federal government and other external research grants. In the context of equation (1), this can be interpreted as high values for the institution-specific error term (v_{jt}) simultaneously causing the numbers of FTSEG students supported by external (A_{jt}) and institutional (I_{jt}) funds to be high. Thus, a spurious positive correlation will arise between the numbers of FTSEG students supported by institutional and external funds and, if we ignore the institutional-specific error term, our estimate of a_3 will likely be biased.

One way around the problem is to try to make the institution-specific error term "observable" by including other variables with which it is likely to be correlated in the analyses (e.g., prestige measures of science and engineering fields in the institution and, in the case of private sector institutions, measures of the institution's wealth). While we intend to pursue such strategies in later research, here we adopt a more parsimonious approach.

If one is willing to treat the institutional-specific error term as fixed over time $(v_{it} = v_i)$, one can obtain data for two time periods (t and s), write equation (1) down for both periods, and then take first differences to obtain

$$(2) \quad I_{jt} - I_{js} = a_1(X_{jt}-X_{js}) + a_2(F_{jt}-F_{js}) + a_3(A_{jt}-A_{js}) + (\epsilon_{jt}-\epsilon_{js})$$

Estimation of (2), in which all variables are expressed as changes, will yield unbiased estimates of the parameter of interest, a_3, because the unobserved fixed effect has been eliminated from the model. Alternatively, one can obtain unbiased estimates by using the two years of data and estimating an augmented version of the original model that includes institution-specific intercept terms.

Table 5 presents estimates that use the latter approach and data from 200 doctorate producing universities on the number of FTSEG students supported on institutional funds during the Fall of 1984 and the Fall of 1983. In columns (1), (2), and (3), the number of FTSEG students supported on external funds in the Fall of each year is divided into the number supported on federal government funds (GTOT), the number supported on foreign funds (FTOT), and the number supported on other United States, primarily corporate and nonprofit organization, funds (OTOT). In columns (4), (5), and (6) these three sources are aggregated to get a total number of FTSEG students supported on external funds (ATOT). Support is defined here to include fellowships, traineeships, research assistantships, teaching assistantships, and other types (primarily tuition waivers). These data come from the annual National Science Foundation Survey of Graduate Science and Engineering Students and Postdoctorates.

Data on enrollments in undergraduate science and engineering courses by institution are not available. What is available from the annual National Center for Education Statistics Higher Educational General Information Survey is the total number of bachelors' degrees awarded in science and engineering fields by an institution in each academic year.[10] While there is not necessarily a one-to-one relationship between changes in course enrollments and changes in graduating majors, the latter is the best proxy available for the former. Changes in degrees granted may well also lag changes in undergraduate enrollments. Hence it is not clear, for example, whether bachelors' degrees granted in science and engineering in 1983-84 (TD) or those granted in 1984-85 (TD2), should be the best predictor of the demand for graduate teaching assistants in the Fall of 1984. Results are presented in Table 5 for specifications that use both measures, as well as their average (TDA).

Finally, no data exist by institution on the number of faculty employed in science and engineering fields. However, from 1973 to 1985 the National Science Foundation's Survey of Scientific and Engineering Personnel Employed at Universities and Colleges collected information from doctorate granting institutions in January of each year on the total number of full-time scientists and engineers employed.[11] These "headcounts" are not restricted to faculty, nor even to doctorates, but probably provide a reasonable approximation to the scale of research and teaching activity in science and engineering fields in the institution. Restricting the "headcount" to full-time employees assures that graduate assistants are not included in the total.

Again, it is not a priori obvious whether the best predictor of the demand for research and teaching assistants in the Fall of a year, would be the number of full-time scientists and engineers employed in the institution in January of that year (FTE), which represents the previous academic year, or in January of the next year (FTE2), which represents the current academic year. Specifications are thus again estimated using both measures, as well as their average (FTEA).[12]

The results displayed in Table 5 suggest that changes in external support for FTSEG students do influence institutional support levels. The institutional responses to changes in the various sources of external support (GTOT, OTOT and FTOT) reported in columns (2), (2), and (3) appear to be quite similar; indeed formal F tests indicate one can not reject the hypothesis that they are all equal. When the various sources are aggregated (ATOT), the specifications in columns (4), (5), and (6), suggest that for every 100 additional FTSEG students supported by external funds, institutions reduce the number of FTSEG students supported by institutional funds by 22 to 23. Whether the money saved was used to support graduate students in other fields, or for other purposes, can not be determined from these data.

The above results assume instantaneous adjustment of the number of FTSEG students supported on institutional funds to annual changes in the number of FTSEG students supported on external funds, the number of degrees granted, and faculty size. However, commitments to support graduate student are often made, at least implicitly, for more than one year at a time. As such, considerable inertia may be built into the process, and the substitution of external for internal funds may be greater in the long-run than in the short-run.

One way to test for this is to build a lagged adjustment process directly into the model. Suppose that equation (1) is replaced by

$$(3) \qquad I^*_{jt} = b_0 + b_1X_{jt} + b_2F_{jt} + b_3A_{jt} + v_j + \epsilon_{jt} \ ,$$

where I^*_{jt} is the number of FTSEG students that institution j desires to support out of its own funds in year t. Because of the inertia caused by multi-year commitments to graduate students and the institution's goal of maintaining relatively stable graduate enrollments and financial commitments to graduate students, it is assumed to adjust to its desired number of institutionally supported FTSEG students only gradually.

Specifically, suppose that,

$$(4) \qquad I_{jt} - I_{jt-1} = \lambda(I^*_{jt} - I_{jt-1}) \ ,$$

where λ $(0 \leq \lambda \leq 1)$ is the fraction of the adjustment between this year's desired and last year's actual number of FTSEG students supported on institutional funds that the institution makes in the year.

Substitution of (3) into (4) yields that

$$(5) \qquad I_{jt} = \lambda b_0 + \lambda b_1X_{jt} + \lambda b_2F_{jt} + \lambda b_3A_{jt} + \lambda v_j + (1-\lambda)I_{jt-1} + \lambda\epsilon_{jt}$$

First differencing to eliminate the unobservable fixed effects, one finds that

$$(6) \qquad I_{jt} - I_{jt-1} = \lambda b_1(X_{jt}-X_{jt-1}) + \lambda b_2(F_{jt}-F_{jt-1}) + \lambda b_3(A_{jt}-A_{jt-1}) + (1-\lambda)(I_{jt-1}-I_{jt-2}) + \lambda(\epsilon_{jt}-\epsilon_{jt-1})$$

Equation (6) differs from equation (2) in that the lagged change (from t-1 to t-2) in the number of FTSEG students supported by institutional funds appears on the right-hand side of (6). With three adjacent years' data on the number of students supported on institutional funds (here data for the Fall of

1984, 1983, and 1982), one can obtain consistent estimates of both the magnitude of the lagged adjustment term (λ) and of the extent to which external support substitutes for internal support (from b_3). To achieve this, an instrumental variable estimator must be used for $I_{jt-1} - I_{jt-2}$ to remove the spurious negative correlation between that variable and the error term $\lambda(\epsilon_{jt}-\epsilon_{jt-1})$ that the first differencing causes.[13]

Estimates of equation (6) appear in Table 6 for the specifications that correspond to those found in columns (1), (2), and (3) of Table 5. Column (a) for each specification uses the actual value of the lagged one year change in the number of FTSEG students supported on institutional funds as an explanatory variable, while column (b) in each specification uses an instrumental variable estimator. The "c" in front of each variable name indicates that each is in first-difference form.

Quite strikingly, in no case can one conclude that λ is statistically significantly different from zero. Put another way, institutions appear to fully adjust the number of FTSEG students they support out of internal funds each year, to their desired levels.

The first three columns of Table 7 report similar estimates for the specifications that aggregate the various external support sources into a single variable (ATOT). Given the statistical insignificance of the lagged change in the number of students supported on internal funds in the previous table, only the specification that uses the actual lagged change is reported here. Again, adjustment appears to be complete (λ=0) and displacement appears to be in the range of -.23.

The last three columns of Table 7 report estimates of specifications in which the extent that the number of FTSEG students supported by institutional funds varies with the number supported on external funds, is allowed to vary across public and private institutions and across research I universities and other doctorate granting institutions. Research I universities are those that award at least 50 Ph.D. degrees annually and receive at least $33.5 million annually in federal research support. Most award considerably more than 50 science and engineering Ph.D.s each year.[14]

These specifications suggest that substitution of external funds supporting graduate students for internal funds supporting graduate students occurs only at the relatively large (in terms of doctorates produced and external research support generated) research I institutions. No such substitution tends to occur in those institutions with smaller scale doctorate and research programs. Furthermore, the extent of substitution of external for institutional funds at research I institutions does not appear to differ between public and private institutions.

IV. Disaggregation by Field

To conclude that, in the aggregate, when the number of FTSEG students supported by external funds increases by 100, institutions reduce the number of FTSEG students they support out of institutional funds by about 22 to 23, is not to say that the response will be the same across all fields. To address the latter issue requires that separate analyses be undertaken by field.

A first approach is to estimate variants of equation (1) using field specific data. Data on institutional and external FTSEG student support levels, the number of full-time scientific and engineering personnel employed, and the number of bachelors' degrees granted, were collected by institution for seven broad science and engineering subfields. Field-specific equations were estimated and the coefficients of the external support variables that were obtained are displayed in panels A and B of Table 8.

The coefficients of the external support variables for each field in panel A come from field-specific specifications that are similar to the specification found in column 1 of Table 5. The effects on internal support levels of changes in federal government, other United States, and foreign support levels often appear to differ from each other at this level of disaggregation. Formal F tests indicate that this is indeed the case.[15] Only for the engineering and mathematical sciences fields can one not reject the hypothesis that the marginal effects of changes in the number of FTSEG students supported by the various external funding sources are equal.

Nonetheless, it is interesting to aggregate the external support variables and estimate what the "average" substitutability of internal for external support is for each field. The results obtained when one does this are found in panel B of Table 8; the coefficient estimates presented there come from field-specific variants of the model estimated in column 4 of Table 5.

External support appears to partially substitute for internal support in six of the seven fields. This substitution is statistically significant in five of these six fields. The magnitude of the substitution ranges from almost 50 percent in the physical sciences, where an additional 100 FTSEG students that are supported on external funds is estimated to reduce the number of internally supported students by about 48, down to about 10 percent in the mathematical sciences. Only for the relatively small environmental sciences fields do increases in external support appear to be associated with increases in internal support.[16] There is weak evidence that fields which, on average, have a greater share of their students supported on institutional funds tend to reduce their own internal support for FTSEG students the most when the number of externally supported students is increased.[17]

The model that underlies the estimates presented above treats each field separately and does not allow for the possible interdependency of internal support levels across fields. So, for example, an increase in the number of students supported on external funds in one field might induce an institution to reduce the number of students it supports out of institutional funds in that field and then use all, or part, of the savings to fund more graduate students out of internal funds in other fields.

One way to test whether such interdependencies exist is to estimate a system of equations of the form:

$$(7) \quad I_{jkt} = a_{0k} + a_{1k}X_{jkt} + a_{2k}F_{jkt} \; a_{3k}A_{jkt} + a_{4k}A_{jt} + v_{jk} + \epsilon_{jkt}$$

$$k = 1, 2, \ldots 7$$

In the above equations, the subscript k indexes the field of study. The number of students in the field supported out of institutional funds (I_{jkt}) is assumed to depend on both the number of students in the field supported by external funds (A_{jkt}) <u>and</u> the number of students supported by external funds in the institution as a whole (A_{jt}). Ceteris paribus, an increase of 100 in the number of students in field k supported by external funds would lead to a change in the number of students in field k supported by internal funds of $100(a_{3k} + a_{4k})$. Similarly, an increase of 100 in the number of FTSEG students supported in the institution as a whole by external funds, with no increase in the number of students in field k supported by external funds, would lead to a change in the number of students supported by internal funds in field k of $100a_{4k}$. A positive estimate of a_{4k} thus indicates that part of any increase in external support for graduate students elsewhere in a university is implicitly used to support graduate students in field k.

Given two years of data, one can first difference the data to eliminate the assumed institution/field fixed effects (v_{jk}) and obtain consistent estimates of the parameters from the system of equations in (7). The coefficients for the number of FTSEG students with external support in the field (ATOT) and in the institution as a whole (TOT) that results are displayed in panels C and D of Table 8. The data used here come from a sample of 113 institutions that reported data in both years for all seven fields. The estimates reported in panel D use the seemingly unrelated regression method to improve efficiency by taking account of the correlation of the error terms across fields within an institution. These estimates vary only marginally, in most cases, from the estimates reported in panel C.

Of key interest are the estimated coefficients for TOT. These estimates suggest that increases in the overall number of students supported by external funds in the science and engineering fields are used partially to subsidize graduate education in the social sciences, psychology, and mathematical sciences. However, only the latter effect is statistically significantly different from zero. Ceteris paribus, an increase of 100 in the number of FTSEG students supported by external funds outside of these fields, leads to an increase in the number of students supported on institutional funds of roughly 4 in the social sciences, 2 in psychology, and 4 in the mathematical sciences. As noted in earlier sections, whether a similar subsidization of graduate education in the humanities occurs can not be ascertained from these

NSF data because they lack information on graduate student support in humanities fields.

V. Disaggregation by Type of Support

FTSEG students who are supported from external funds often have different *types* of support than those who are supported from institutional funds. For example, the former are more likely to receive research assistantships, while the latter are more likely to receive teaching assistantships.[18]

It is possible that an institution that receives an increase in one type of external support for FTSEG students may reduce the number of students that it supports out of institutional funds on that type of support and use some, or all, of the savings to increase the number of FTSEG students it supports internally on other types of support. So, for example, an increase in external support for research assistants may lead an institution to reduce the number of research assistants it offers out of institutional funds, but to increase its allocation of internal funds to teaching assistants and fellowships.

To allow for this possibility, equation (1) can be generalized to the four equation system

$$(8) \quad IT_{jt} = a_{0T} + a_{1T}X_{jt} + a_{2T}F_{jt} + \Sigma\, a_{3TZ}AZ_{jt} + vT_{jt} + \epsilon_{jTt}$$

$$T,\ Z = SUM,\ TA,\ RA,\ OTH$$

The numbers of FTSEG students supported from institutional and external funds are decomposed in each case into the numbers supported on fellowships and traineeships (SUM), on teaching assistantships (TA), on research assistantships (RA), and on other types – primarily tuition waivers – of support (OTH). Assuming that the institution-specific error terms are fixed over time ($vT_{jt} = vT_j$), with two years of data one can again estimate the equations in first difference form to obtain unbiased estimates.

Estimates of this system appear in Table 9. While an increase in the number of FTSEG students supported by externally funded research assistantships is associated with a decrease in the number of FTSEG students supported by institutional research assistantships, a large share of these "saved" institutional funds are redirected towards increasing the number of students supported by institutional teaching assistantships and fellowships. An increase in external funding for teaching assistantships leads to a substantial reduction in institutional teaching assistantships. In contrast to the research assistantship results, however, none of these "saved" institutional funds appear to be diverted to other types of support for graduate students. Finally, changes in external fellowships and traineeships and in other types of support, each seem to affect primarily other, rather than the same, internal types of support.

Similar estimates of the coefficients of the various external types of support variables appear in Table 10 for analyses done separately by field. Increases in external support for fellowships and traineeships lead to statistically significant reductions in institutional support for fellowships in 5 of the 7 fields. Similar statistically significant "own substitution" effects occur in 4 of the 7 fields for research assistantships and 5 of the 7 fields for teaching assistantships. Many statistically significant "cross substitution" effects are present, although the pattern is not always consistent across fields. For example, an increase in external fellowship support is associated with an increase in institutional teaching assistant support in the life sciences, but a decrease in such support in the social sciences. Findings of this type confirm the need to undertake separate analyses by field.

VI. Concluding Remarks

This paper has demonstrated that doctorate-producing universities respond to changes in the number of FTSEG students supported on external funds by altering the number of FTSEG students that they support on institutional funds. Institutional adjustment to changes in external support levels appear to be quite rapid. However, in the aggregate, the magnitude of these responses are quite small. An increase of 100 in the number of FTSEG students supported by external funds is estimated to reduce the number supported on institutional funds by 22 to 23. Since some of the institutional funds that are "saved" may be redirected to support graduate students in the humanities and other fields not represented in the data, the total affect of such a policy change on institutional support for graduate students is probably somewhat smaller.

Two qualifications are in order here. First, institutions are likely to react quite differently to changes in external support levels that they perceive as being transitory than to changes that they perceive as being permanent.[19] Transitory increases, which are not expected to recur in future years, are unlikely to lead to large reallocations of institutional funds. Institutions may treat such increases as windfalls and compensatingly reduce their own expenditures for graduate support temporarily.

In contrast, permanent increases, which institutions may view as fundamentally altering their wealth levels, are likely to lead to larger institutional commitments to graduate education and thus to less substitution of external for institutional funds. To the extent that the variation in changes in external support levels across institutions during a two-year period reflect primarily transitory fluctuations, our estimates may thus well overstate the extent to which institutions would reduce their own internal support for FTSEG students in response to an increase in external support that was perceived to be more permanent.

Second, changes in external support levels in one year may affect the intertemporal allocation of institutional funds to support FTSEG students.[20] For example, the provision of external fellowships to support first-year entering graduate students in a field in year t might induce an institution to reduce its internal support for entering students in the field in year t. However, to the extent that substitution was not one-for-one, the size of its entering class will have increased and thus the number of advanced FTSEG students who "need" support will increase in subsequent years. To the extent that an institution uses some, or all of, the "saved" internal funds in year t to support an increased number of FTSEG students in subsequent years, focusing on contemporaneous responses, as we have done, will overstate the extent of substitution of external for institutional funds. A similar result would occur if institutions that previously provided support to students for four years used some of the saved internal funds in year t to provide fifth year support in year t+4 for some of the new students who entered in year t.

Policymakers also need be concerned that the magnitudes of the responses appear to differ significantly across fields. There is also evidence that even within science and engineering there is some fungibility of external support across fields. In particular, institutional support for the social sciences, psychology, and the mathematical sciences appears to increase somewhat in response to increases in external support to other science and engineering fields which permit institutions to reduce their own support to these other fields.

Finally, policymakers need be concerned that changes in external support levels influence the distribution of institutional support by type of support. For example, in the aggregate, an increase in the number of FTSEG students supported by externally funded research assistantships is associated with a decrease in the number of FTSEG supported by institutional research assistantships. However, a share of these "saved" funds is redirected to increasing the number of students receiving teaching assistantships out of institutional funds. It is often conjectured, although it has not been proven, that teaching assistantships slow down degree progress relative to research assistantships.[21] As such, the latter shift may partially frustrate the goal of policymakers when they increase external support for research assistantships for FTSEG students.

The analyses reported in this paper are only a start at addressing the issues we pose. To a large extent they focus on changes in external and institutional support levels between the Fall of 1983 and the Fall of 1984. While this was a period in which approximately half of the institutions in the sample faced increases in external support and half decreases, one wonders whether institutional responses would differ in periods when external support changes all tended to move in one direction and, more generally, whether institutional responses are stable over time. As discussed above, our focus on this one-year period also precluded us from distinguishing between institutional responses to transitory and permanent changes in external support for graduate students and from analyzing how such changes influence institutions' intertemporal decisions on allocating internal funds. Subsequent research by us will attempt to use a panel of 11 years' data from these institutions, that covers the 1974 to 1984 period, to address these issues.

Throughout the paper differences in institutional characteristics that might influence universities' desire and willingness to support graduate students are, for the most part, "buried" in the unobservable fixed effects. Generalizations of the empirical models could productively be explicitly tied to models of university utility maximization subject to budget constraints.[22] One implication that likely flows from such an approach is that institutional support for graduate students should depend on the "wealth" levels of institutions. This suggests that measures of state budgetary tightness (in the public sector) or endowment strength (in the private sector) are candidates to be added to the empirical models. Similarly, an institution's willingness to support graduate students in a field may well depend upon the "quality", or the recent change, in the "quality" of the field and of other fields in the institution. As such, estimation of whether the extent that external funds substitute for internal funds varies with field "quality" measures is also clearly warranted.

ACKNOWLEDGEMENTS

Irving M. Ives Professor of Industrial and Labor Relations and Economics at Cornell University and Research Associate at the National Bureau of Economic Research, and Ph.D. candidates in Labor Economics at Cornell University, respectively. We are grateful to Alan Fechter at the National Research Council for encouraging us to undertake this study, and to Cornell University, the NBER and the National Science Foundation for research support. An earlier version of the paper was presented at the May 1991 NBER "Conference on the Economics of Higher Education," and we are also grateful to the discussant Michael McPherson, other participants at the conference, and numerous colleagues for their comments on that version. The views expressed are solely our own and do not necessarily reflect the views of any of the above-mentioned institutions or individuals.

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Footnotes

1. See, for example, Bowen and Sosa (1989), National Science Foundation (1989), National Research Council (1990), and Atkinson (1990).

2. See Ehrenberg (1991), Chapter 7.

3. Bowen and Sosa, Table 8.5

4. Ehrenberg, Table 6.4

5. National Research Council (1989), Table I. Bowen, Lord and Sosa (1991) have shown that part of the reported increase in times-to-degree in the humanities is a statistical artifact caused by the grouping of individuals by year of degree, rather than by year of program entrance, during a period in which the size of entering cohorts was decreasing.

6. See Ehrenberg, Chapter 8.

7. See, for example, Johnson and Tomola (1977), Borus and Hamermesh (1978), and Adams, et al. (1983). More generally, economists have a long tradition of analyzing how various types of federal grants influence state and local government expenditure and taxation decisions (see Gramlich and Galper 1973) and recently economists have also analyzed the extent to which changes in state aid to local school districts influence teacher salaries, student/teacher ratios and local property tax rates (see Ehrenberg and Chaykowski 1988).

8. If the percentage of FTSEG students whose major source of support came from the federal government remained at its 1974 level of 24.6, about 11,000 more FTSEG students would have been supported by federal funds in 1988. About 113,000 FTSEG students were supported by institutional funds that year. If the percentage of FTSEG students whose major source of support came from

institutional funds had remained at its 1974 level of 38.5, about 10,000 fewer students would have been supported by institutional funds in 1988.

9. In the NSF data federal fellowships are offered to students who then decide which institution to attend, while traineeships are granted to institutions who then decide to which students to offer the awards.

10. In recent years the scope of the HEGIS survey has been expanded and it is now called the Integrated Postsecondary Education Data System (IPEDS).

11. The cessation of this survey in January of 1985 precludes us from using more recent data on institutional and external support for graduate students in our analyses.

12. All of the specifications in Table 4 are estimated using the ABSORB command in Proc GLM in SAS.

13. The variables used as instruments include I_{jt-1}, and the values from periods t-1 and t-2 of all the other explanatory variables in the model.

14. For example, in 1988, 70 institutions awarded at least 100 science and engineering Ph.D.s, with Berkeley alone awarding 576. See National Science Foundation, 1989, Table 10.

15. The computed F statistics are:

Engineering	$F(2,137)=1.22$	Environ. Sciences	$F(2,147)=5.47$
Physical Sciences	$F(2,180)=3.48$	Psychology	$F(2,176)=3.73$
Life Sciences	$F(2,183)=4.61$	Mathematics	$F(2,181)=1.04$
Social Sciences	$F(2,179)=3.59$		

In each case the critical value to reject the null hypothesis at the .05 level is 3.09.

16. In October of 1984, only 4.6 percent of all FTSEG students in doctorate-granting institutions were enrolled in environmental science fields (National Science Foundation, 1990, Table C1).

17. Across the seven fields the correlation of the average proportion of supported students in a field supported by institutional funds and the estimate of the substitution of external for internal funds in the field (the coefficients in panel B) is −.32. However, if one drops environmental sciences from the sample, the correlation across the six remaining fields falls to under −.2.

18. More generally, in the Fall of 1984 the proportions of FTSEG students supported from institutional and external funds, by type of support, in our sample were:

	Fellowship/ Traineeship	Research Assistantship	Teaching Assistantship	Other
Institutional	.140	.176	.574	.110
External	.279	.515	.018	.188

19. We owe this point to Michael McPherson.

20. We owe this point to Robert Hauser.

21. See Ehrenberg (1991), Chapter 8.

22. See, for example, Garvin (1980) and James (1990).

Table 1

Full-Time Science and Engineering Graduate Students with Federal Support in Doctorate-Granting Institutions

Fall of	Number With Federal Support (A)	(B)	Total Number (A)	(B)	Share With Federal Support (A)	(B)
1966	44,612		118,273		.377	
1969	51,620		141,199		.366	
1970	50,256		145,970		.344	
1971	45,101		142,169		.317	
1972	45,029		149,937		.300	
1974	43,089	47,989	169,145	195,455	.255	.246
1975	48,365	48,249	210,641	210,321	.230	.229
1976	48,508	48,594	215,355	214,094	.225	.227
1977	50,308	50,378	218,226	217,454	.231	.232
1978		51,273		216,613		.237
1979		52,874		223,414		.237
1980		52,939		230,535		.230
1981		50,897		234,194		.217
1982		47,206		236,939		.199
1983		47,333		243,661		.194
1984		47,476		245,530		.193
1985		48,716		248,782		.196
1986		51,060		258,055		.198
1987		53,093		263,003		.202
1988		54,852		268,385		.204

Table 1 (continued)

Source: Authors' computations from:

A) National Science Foundation, Graduate Student Support and Manpower Resources in Graduate Science Education, Fall 1965 and Fall 1966 (Figure 9), Fall 1969 (Table C10a), Fall 1970 (Table C81), Fall 1971 (Table C9); National Science Foundation, Graduate Science Education: Student Support and Postdoctorals, Fall 1972 (Table C14); National Science Foundation, Graduate Science Education: Student Support and Postdoctorals, Detailed Statistical Tables, Fall 1974 (Table B13), Fall 1975 (Page 11), Fall 1976 (Table B10), Fall 1977 (Table B10).

B) National Science Foundation, Academic Science/Engineering: Graduate Enrollment and Support, Fall 1988 (Table C17), Fall 1981 (Table C14).

Table 2

Percentage of Full-Time Science/Engineering Graduate Students by Major Source of Support in Doctorate Granting Institutions

Year	Percent Federal (A)	Percent Federal (B)	Percent Institutional (A)	Percent Institutional (B)	Percent Other Outside Support (A)	Percent Other Outside Support (B)	Percent Self-Support (A)	Percent Self-Support (B)
1966	40.9		35.0		6.1		18.0	
1969	36.6		35.7		9.0		18.6	
1970	34.4		36.9		9.2		19.5	
1971	31.7		37.0		8.8		22.4	
1972	30.0		38.6		8.3		23.1	
1974	25.5	24.6	39.9	38.5	8.9	8.4	25.8	28.6
1975		22.9		36.7		8.0		32.4
1976	22.5	22.7	37.0	37.0	8.2	8.3	32.3	32.0
1977	23.1	23.2	36.9	37.0	8.5	8.4	31.6	31.5
1978		23.7		36.8		8.9		30.6
1979		23.7		37.1		9.0		30.3
1980		23.0		37.6		9.1		30.3
1981		21.7		38.5		9.6		30.2
1982		19.9		39.4		10.0		30.8
1983		19.4		39.5		10.0		31.0
1984		19.3		40.6		10.0		30.1
1985		19.6		41.0		10.6		28.9
1986		19.8		41.6		10.2		28.4
1987		20.2		41.9		9.5		28.4
1988		20.4		42.2		9.5		27.8

Source: Authors' computations from sources cited in Table 1.

Table 3

Percentages of Full-Time Science/Engineering Graduate Students in Doctorate Granting Institutions, by Field and Types of Major Support: 1968, 1974, 1988

Field	(A) 1968	(A) 1974	(B) 1974	(B) 1988	Field	(A) 1968	(A) 1974	(B) 1974	(B) 1988
TOTAL					AGRICULTURE[a]				
% Fellowship	32.0	20.1	19.7	14.0	% Fellowship	21.6	10.1	10.1	5.8
% RA	22.1	21.9	20.3	27.4	% RA	47.6	45.9	45.8	51.1
% TA	23.3	24.7	23.6	22.9	% TA	8.3	9.0	7.8	9.6
% Other	22.6	33.3	36.4	35.7	% Other	32.5	35.0	36.3	33.4
ENGINEERING					BIOLOGY				
% Fellowship	29.4	15.2	14.3	8.7	% Fellowship	38.0	24.7	25.7	23.4
% RA	29.5	34.2	33.0	37.8	% RA	9.5	9.6	20.3	36.4
% TA	13.2	15.2	15.4	17.7	% TA	30.2	35.8	26.5	21.6
% Other	27.9	35.4	37.3	35.8	% Other	22.3	29.8	27.5	18.6
PHYSICAL SCIENCE					HEALTH				
% Fellowship			11.6	8.5	% Fellowship			39.6	27.3
% RA			30.1	42.6	% RA			5.5	12.1
% TA			47.3	40.4	% TA			11.0	9.2
% Other			10.9	8.5	% Other			43.9	51.4

Table 3 (continued)

Field	(A) 1968	(A) 1974	(B) 1974	(B) 1988	Field	(A) 1968	(A) 1974	(B) 1974	(B) 1988
ENVIRON SCIENCE					PSYCHOLOGY				
% Fellowship			10.7	9.1	% Fellowship	41.1	24.7	24.2	11.0
% RA			32.0	38.6	% RA	15.2	12.4	12.1	14.9
% TA			24.2	24.6	% TA	21.2	21.6	20.8	22.0
% Other			33.1	27.7	% Other	24.5	41.2	42.9	52.1
MATH & CIS					SOCIAL SCIENCES				
% Fellowship	27.2	10.6	9.5	7.5	% Fellowship	36.2	22.4	21.0	17.4
% RA	8.6	11.3	10.3	15.6	% RA	10.5	11.3	11.0	11.8
% TA	41.3	50.4	46.5	40.2	% TA	18.5	19.4	17.5	20.2
% Other	22.8	27.7	33.7	36.9	% Other	34.8	46.9	50.5	50.6

[a]1969 figures are reported in the 1968 column.

Source: Authors' computations from sources cited in Table 1.

Table 4

Percentage of Science/Engineering Graduate Students That Are Enrolled Part-Time at Doctorate-Granting Institutions

Year	Total (A)	Total (B)	Engineering (A)	Engineering (B)	Psychology (A)	Psychology (B)	Social Sciences (A)	Social Sciences (B)
1965	27.4		43.9		16.3		23.2	
1968	23.1		41.1		12.5		22.1	
1971	21.9		36.2		12.5		24.8	
1974	21.4	26.3	37.5	40.5	20.4	24.0	25.7	28.0
1977		29.1		43.6		24.2		31.1
1980		30.9		40.2		26.6		35.8
1983		32.0		38.8		28.4		33.5
1988		31.5		36.4		28.5		34.3

Source: Authors' computations from the sources cited in Table 1.

Table 5

Determinants of Institutional Support for Full-Time Science and Engineering Graduate Students in Research and Doctorate Universities, Fall 1983 and Fall 1984: Fixed Effects Model (absolute value t statistics)

	ITOT					
	(1)	(2)	(3)	(4)	(5)	(6)
GTOT	-.214 (1.9)	-.248 (2.3)	-.240 (2.0)			
OTOT	-.209 (2.0)	-.210 (2.0)	-.199 (1.9)			
FTOT	-.286 (1.9)	-.238 (1.6)	-.228 (1.5)			
ATOT				-.224 (3.3)	-.231 (3.5)	-.221 (3.4)
TD	-.001 (0.0)			-.001 (0.0)		
FTE	.113 (3.4)			.116 (3.5)		
TD2		.080 (1.9)			.082 (2.0)	
FTE2		.218 (4.0)			.217 (4.2)	
TDA			.074 (1.3)			.075 (1.4)
FTEA			.208 (4.5)			.207 (4.5)
R^2	.997	.997	.997	.997	.997	.997
FICE/DOF[a]	200/194	197/190	197/189	200/191	197/192	197/191

Table 5 (continued)

[a]FICE - number of institutional dummy variables included in the analysis. DOF - number of degrees of freedom.

where

ITOT - number of full-time science and engineering graduate students (FTSEG) supported by institutional and state funds on fellowships, traineeships, research assistantships, teaching assistantships or other types (primarily tuition waivers) of support in the fall of year t

GTOT - number of FTSEG supported by federal government funds in the fall of year t

FTOT - number of FTSEG supported by foreign funds in the fall of year t

OTOT - number of FTSEG supported by other United States (primarily corporate and nonprofit) funds in the fall of year t

ATOT - sum of GTOT, FTOT, and OTOT

TD - total bachelors' degrees in science and engineering awarded by the institution in the academic year

TD2 - same as TD but for academic year t+1

TDA - the average of TD and TD2

FTE - total full-time scientific and engineering personnel employed by the institution in January of year t

FTE2 - same as FTE but for January of year t+1

FTEA - the average of FTE and FTE2

Table 5 (continued)

Sources: 1) National Science Foundation, Survey of Graduate Science and Engineering Students and Postdoctorates: Fall 19xx (ITOT, FTOT, OTOT, GTOT).

2) National Science Foundation, Survey of Scientific and Engineering Personnel Employed at Universities and Colleges: January 19xx (FTE, FTE2, FTEA).

3) National Center for Education Statistics, Higher Educational General Information Survey (HEGIS): Academic Year 19xx (TD, TD2, TDA).

1, 2 and 3 are all available as part of the National Science Foundation's Computer Aided Science Policy Analysis and Research Database System (CASPAR). However, ITOT is not reported in CASPAR and the underlying data tapes must be used to obtain this variable.

Table 6

Determinants of Institutional Support for Full-Time Science and Engineering Students in Research and Doctorate Universities: Lagged Adjustment Model with Fixed Effects
(absolute value t statistics)

	CITOT					
	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)
CGTOT	-.223 (2.1)	-.242 (2.3)	-.249 (2.4)	-.257 (2.4)	-.247 (2.4)	-.260 (2.5)
CFTOT	-.147 (1.0)	-.173 (1.2)	-.150 (1.0)	-.174 (1.1)	-.124 (0.8)	-.146 (1.0)
COTOT	-.298 (2.8)	-.254 (2.5)	-.254 (2.4)	-.241 (2.3)	-.260 (2.5)	-.233 (2.3)
CFTE	.096 (3.1)	.095 (3.0)				
CTD	-.031 (0.9)	-.015 (0.4)				
CFTE2		.149 (2.7)	.152 (2.7)			
CTD2		.041 (1.0)	.047 (1.1)			
CFTEA				.163 (3.5)	.164 (3.5)	
CTDA				.002 (0.0)	.024 (0.4)	
CITOTL[a]	.096 (1.6)	-.005 (0.0)	.055 (0.9)	-.017 (0.1)	.071 (1.1)	-.002 (0.0)
$\bar{R}^2$	.090	.078	.083	.079	.010	.093
DOF	187	187	188	187	187	187

[a]The actual value of CITOTL is used in the regressions in columns (a), while an instrument is used in the columns (b) regressions.

where

CITOT ITOT(84) - ITOT(83)
CGTOT GTOT(84) - GTOT(83)
CFTOT FTOT(84) - FTOT(83)
COTOT OTOT(84) - OTOT(83)

CFTE FTE(84) - FTE(83)
CTD TD(84) - TD(83)
CFTE2 FTE(85) - FTE(84)
CTD2 TD(85) - FTE(84)

CFTEA [FTE(85) - FTE(83)]2
CTDA [TD(85) - TD(83)]2
CITOTL ITOT(83) - ITOT(82)

See Table 5 for variable definitions and sources.

Table 7

Determinants of Institutional Support for Full-Time Science and Engineering Students in Research and Doctorate Universities: Lagged Adjustment Model With Fixed Effects and All External Support Sources Aggregated Together (absolute value t statistics)

	CITOT					
	(1)	(2)	(3)	(4)	(5)	(6)
CATOT	-.239 (3.7)	-.234 (3.7)	-.231 (3.7)	.121 (0.7)	.143 (0.8)	.128 (0.7)
CATOT*R1			-.406 (3.0)	-.405 (3.1)	-.382 (2.9)	
CATOT*P			-.127 (0.8)	-.145 (0.9)	-.143 (0.9)	
CFTE	.093 (3.0)			.083 (2.7)		
CTD	-.026 (0.7)			-.039 (1.1)		
CFTE2	.146 (2.7)			.140 (2.6)		
CTD2	.041 (1.0)			.045 (1.1)		
CFTEA		.158 (3.4)			.145 (3.1)	
CTDA		.006 (0.1)			-.007 (0.1)	
CITOTL	.078 (1.4)	.047 (0.8)	.060 (1.0)	.046 (0.8)	.009 (0.1)	.028 (0.4)
$\bar{R}^2$	.095	.090	.106	.131	.128	.138
DOF	189	190	189	187	188	187

All variables are defined in Tables 5 and 6 save for
CATOT - (GTOT(84) + FTOT(84) + OTOT(84)) - (GTOT(83) + FTOT(83) + ITOT(83))
R1 - 1-research I institution, 0-other
P - 1-public institution, 0-other

Table 8

Determinants of Institutional Support for Full-Time Science and Engineering Graduate Students in Research and Doctorate Universities, Fall 1983 and Fall 1984: Fixed Effects Model, by Field

	Engineering	Physical Sciences	Life Sciences	Social Sciences	Environmental Sciences	Psychology	Mathematical Sciences
A) GTOT	-.148 (1.1)	-.522 (6.5)	-.486 (7.3)	.094 (0.7)	.316 (2.6)	-.659 (4.6)	-.044 (0.2)
FTOT	-.059 (0.3)	.425 (1.2)	-.464 (2.1)	-.346 (3.0)	.434 (2.1)	1.479 (1.6)	.193 (0.8)
OTOT	-.270 (2.9)	-.480 (3.4)	.036 (0.2)	-.450 (3.3)	-.108 (0.8)	-.163 (1.0)	-.221 (1.6)
FICE	142	187	190	186	151	185	188
B) ATOT	-.204 (2.7)	-.479 (7.1)	-.380 (7.4)	-.219 (3.2)	.251 (2.8)	-.412 (3.7)	-.104 (1.2)
C) ATOT	-.199 (1.9)	-.653 (6.7)	-.328 (3.7)	-.318 (3.3)	.232 (2.0)	-.499 (4.5)	-.162 (1.6)
TOT	-.028 (0.6)	-.021 (1.0)	-.019 (0.4)	.042 (1.0)	-.001 (0.1)	.018 (1.4)	.038 (2.0)
D) ATOT	-.149 (1.5)	-.633 (6.8)	-.310 (3.7)	-.318 (3.4)	.233 (2.1)	-.517 (4.8)	-.171 (1.8)
TOT	-.040 (1.0)	-.024 (1.2)	-.026 (0.5)	.043 (1.0)	-.001 (0.0)	.019 (1.5)	.038 (2.0)
FICE	113	113	113	113	113	113	113

Table 8 (continued)

where

A) Same specification as Table 5, column (1), but all data field-specific.

B) Same specification as Table 5, column (4), but all data field-specific.

C) Same as B), but TOT added.

D) Same as C), but seemingly unrelated regression method used.

where

TOT - sum of ATOT across all seven fields.

FICE - number of institutions included in the analyses.

Table 9

Determinants of Institutional Support for Full-Time Science and Engineering Graduate Students in Research and Doctorate Universities, Fall 1983 and Fall 1984: Fixed Effects Model, by Type of Support (absolute value t statistics)

	ISUM	IRA	ITA	IOTH
ASUM	-.066 (1.2)	-.039 (0.4)	-.086 (1.2)	.122 (2.1)
ARA	.091 (2.1)	-.205 (2.5)	.106 (1.8)	-.082 (1.8)
ATA	-.172 (0.8)	-.602 (1.5)	-.796 (2.7)	-.267 (1.1)
AOTH	-.148 (3.3)	-.189 (2.3)	-.067 (1.1)	.013 (0.3)
FTE	.019 (1.3)	.058 (2.3)	.015 (0.8)	.027 (0.1)
TD	.001 (0.0)	-.008 (0.3)	-.013 (0.7)	.001 (0.1)
R^2	.990	.990	.998	.961
FICE/DOF	200/188	200/188	200/188	200/188

where the number of FTSEG supported by

ISUM institutional and state funds on fellowships and traineeships

ITA institutional and state funds on teaching assistantships

IRA institutional and state funds on research assistantships

IOTH institutional and state funds, other (primarily tuition waivers) types of support

ASUM same as ISUM, but supported by federal government, foreign, or other United States (FFO) funds

ARA same as IRA, but supported by FFO funds

ATA same as ITA, but supported by FFO funds

AOTH same as IOTH, but supported by FFO funds

Other variables are defined in Table 5.

Table 10

Determinants of Institutional Support for Full-Time Science and Engineering Graduate Students in Research and Doctorate Universities, Fall 1983 and Fall 1984: Fixed Effects Model, by Field and Type of Support (absolute value t statistics)

Field	ISUM	IRA	ITA	IOTH
Engineering				
ASUM	-.116 (2.4)	.080 (0.6)	-.167 (1.4)	-.011 (0.2)
ARA	-.022 (1.1)	-.089 (1.6)	.042 (0.9)	-.144 (5.2)
ATA	-.063 (0.5)	-.657 (1.7)	-.870 (2.7)	-.437 (2.3)
AOTH	-.048 (1.9)	-.045 (0.6)	.072 (1.2)	-.042 (1.2)
Physical Sciences				
ASUM	-.189 (3.5)	-.139 (1.7)	.089 (0.8)	-.003 (0.1)
ARA	-.090 (2.8)	-.243 (4.9)	-.310 (4.5)	.030 (1.8)
ATA	-.028 (0.1)	.181 (0.4)	-1.609 (2.6)	-.120 (0.8)
AOTH	-.014 (0.2)	.041 (0.4)	-.447 (3.0)	.016 (0.5)
Life Sciences				
ASUM	-.126 (2.5)	-.311 (3.1)	.222 (3.2)	.055 (1.3)
ARA	.112 (3.5)	-.452 (7.0)	-.087 (2.0)	-.053 (2.0)
ATA	-.190 (1.1)	-.480 (1.4)	-.200 (0.8)	-.067 (0.5)
AOTH	.075 (1.3)	-.336 (2.9)	.050 (0.6)	.043 (0.9)
Social Sciences				
ASUM	-.174 (3.2)	.064 (1.3)	-.094 (2.0)	-.069 (1.2)
ARA	.125 (0.9)	-.104 (0.8)	-.016 (0.1)	.143 (1.0)
ATA	.402 (0.7)	-.299 (0.6)	-.517 (1.1)	1.220 (2.1)
AOTH	-.302 (3.9)	-.052 (0.8)	.003 (0.1)	.092 (1.2)

Table 10 (continued)

Field	ISUM	IRA	ITA	IOTH
Environmental Sciences				
ASUM	.057 (0.8)	−.018 (0.2)	.264 (2.7)	.051 (0.7)
ARA	.029 (0.5)	−.079 (1.4)	.074 (1.0)	−.017 (0.3)
ATA	.080 (0.3)	−.222 (0.8)	−.231 (0.6)	−1.379 (5.2)
AOTH	.073 (0.8)	−.030 (0.3)	.188 (1.5)	.079 (0.9)
Psychology				
ASUM	−.126 (1.1)	.069 (0.6)	−.215 (1.7)	−.609 (3.3)
ARA	−.241 (2.1)	−.126 (1.1)	−.096 (0.8)	.025 (0.1)
ATA	.099 (0.3)	−.088 (0.3)	−1.072 (3.3)	−.214 (0.5)
AOTH	−.120 (1.9)	.037 (0.6)	−.090 (1.3)	−.050 (0.5)
Mathematical Sciences				
ASUM	−.548 (4.5)	.106 (1.1)	.310 (1.7)	.284 (4.1)
ARA	.127 (1.5)	−.444 (6.7)	.182 (1.5)	−.181 (3.7)
ATA	−.178 (0.6)	−.326 (1.5)	−1.317 (3.2)	.162 (1.0)
AOTH	.114 (1.4)	.061 (1.0)	.024 (0.2)	−.015 (0.3)

where the underlying model is that estimated in Table 9 save that all variables are field specific here