Competitive Grants and the Funding of Agricultural Research in the U.S.

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Introduction and Background

Globally, changes in the political economy of public finance, new technologies, and privatization of agricultural research have led to funding constraints for public agricultural research organizations at the same time they face demands to broaden their research focus. These pressures, in turn, have led to calls for greater research efficiency. Changes in funding mechanisms have been proposed as a means of increasing efficiency.

Historically, the U.S. public agricultural research system has been characterized by a decentralized state-led structure, which fosters geographically-specific applied research (Schultz, Huffman and Evenson). State institutions relied heavily on state funds, as well as federal funds allocated by formula. The U.S. agricultural research system has often been cited for exemplary performance and organization (e.g. Nelson and Langlois, Just and Huffman, Huffman and Evenson, Ruttan). U.S. agriculture has maintained rates of total factor productivity growth which are high relative to industry and to agriculture in other countries.

The decentralized and applied nature of agricultural research has come under criticism, however. In particular, two influential reports published by the National Academy of Sciences (NAS, 1972) and by the Rockefeller Foundation (1982) argued that agricultural research had become overly focused on applied research, and had moved too far from the cutting edge of biological research. The NAS report, known as the Pound Report and the Rockefeller Foundation Report, known as the Winrock Report, both called for research policy makers to increase peer review and competition for research funds. They also recommended that Land Grant Universities (LGUs) shift to more basic biological research and shift away from commodity specific applied research.

The funding of State Agricultural Experimentation Stations (SAESs) on a formula basis was initially established under the Hatch Act of 1887. Formula funding allocations today are based (among other things) on the number of farms and percentage of rural population in a state. The Winrock Report went further than the Pound Report in arguing for a shift in funding mechanisms from formula funding to competitive grants, emphasizing basic biological research and biotechnology development. The Winrock Report also recommended that a major goal of restructuring should be the maintenance of U.S. leadership in biotechnology. The underlying rationale for the emphasis of the Pound and the Winrock Reports was that biotechnological breakthroughs based on basic biological research were needed to maintain historical rates of agricultural productivity growth. It was argued that geographically specific applied commodity research would not generate needed breakthroughs to achieve this goal.

In 1978, the USDA Competitive Research Grant Office began to distribute funds on a competitive basis. The 1990 Farm Bill extended the role of competitive grants with the National Research Initiatives for Food, Agriculture and Environment (NRI). The NRI administers competitive grants, which are peer-reviewed. Four grant types are used: fundamental research by multidisciplinary teams, mission-linked research by multidisciplinary teams, research by individual investigators and grants to research entities needing to strengthen their capacity (National Research Council, 1994). The basic nature of competitive grants is illustrated by the fact that up to 80% of these grants may be for fundamental research (OTA, 1995).

Some critics disagreed with these funding recommendations. Specifically, Buttel (1986) warned that a shift toward competitive grants could redirect public resources toward the goals of private biotechnology firms and away from research with the highest social rates of return. He also hypothesized that states closer to the frontier of biological research would fare better, thus skewing the geographic distribution of USDA research funds. Just and Huffman (1992) have also argued that a shift toward competitive grants would undermine researcher autonomy and divert attention from actual research to grant writing. Huffman and Just (1998, 1999) use the theory of optimal contracting to argue that peer-reviewed and peer-ranked competitive research funding is socially inefficient relative to optimal incentive contracts.

Much of the debate concerning the efficacy with which competitive grants achieve national goals has been based on theoretical grounds.[1] Consequently, we wanted to evaluate different funding mechanisms empirically. This paper examines patterns of USDA funding to states and addresses concerns over shifts in research resources. First, we analyze the nature and historical use of different funding instruments. Second, we present quantitative evidence about how a shift away from formula funds has affected (a) the type of research conducted and (b) the distribution of funds across states. Finally, we model the factors associated with those states receiving greater levels of competitive grants. The following section describes the data and methodologies we used to assess funding instruments.

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1 Recent policy analysis (Alston and Pardey 1996) summarizes many of the arguments both for and against moving to funding a greater proportion of agricultural research through competitive grants.

Data & Methods

The research funding data used are drawn from the Inventory of Agricultural Research. These data are maintained by the Current Research Inventory System (CRIS) of USDA. Research funds are collected for State Agricultural Experiment Stations (SAESs), Forestry Schools, Colleges of 1890 and Tuskegee University, Colleges of Veterinary Medicine and other institutions.

The data cover USDA research funding to state-level research institutions between 1983-1997 via four instruments: formula funds, competitive grants, Congressionally-awarded special grants, and contracts, grants, and cooperative agreements from USDA research agencies. Formula funds consist of funds that are allocated equally to all states and funds allocated by formula.[2] Competitive grant funds are allocated by panels of relevant scientific peers after consideration of research proposals submitted to the review panel. Special Grants are determined by Congress.[3]

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[2] Formula funds originated with the Hatch Act (Huffman & Evenson). The Amended Hatch Act (1955) established a formula for distributing Hatch Act funds. In addition to Hatch funds, the McIntire-Stennis Act provided for research funds to SAES and Forestry Schools. Evans-Allan appropriations are formula funds granted to the Colleges of 1890 and Tuskegee University. Together, these three sources comprise "Formula Funding".

[3] The Special Research Grants Act of 1965 created a mechanism for the distribution of funds to SAES, public institutions and individuals to study problems of concern to USDA (Huffman & Evenson).

SAES and others can receive research funds through contracts, grants and cooperative agreements (henceforth called Cooperative Agreements) from USDA agencies which perform research.[4]

Composition of Research Funded by Different Instruments

One indication of the different roles played by the four funding instruments is the areas of research which they fund. Figures 2-5 show the percentage of SAES funds from the four instruments allocated to different Research Goals as defined in the Inventory of Agricultural Research (CSRS, various years). This provides an indication of what types of research are being funded by different instruments. Formula Funds (Figure 2) represent the majority of these funds, hence they closely resemble the distribution of the combined funds. Formula funds (like combined funds) have remained fairly consistent over time. In 1997, the leading research categories were production-related research (33% of funds), Pest and Disease Protection (21%), Natural Resource Management (approximately 14%) and research to improve the community and environment (10.5%). Competitive Grants are concentrated heavily in production-related research (see Figure 3), which received about 42% of all these funds. Pest and Disease Protection accounts for about 24% of Competitive Grants. Originally, Competitive Grants were even more focused, with almost 70% of funds going to production-related research. Over time,

[4]Other sources of SAES research appropriations are additional Cooperative State Research Service monies, Animal Health and Disease Research funds, research agreements with other federal agencies, State appropriations, industry funds, and self-generated funds

competitive grants have become broader in their research focus, with growth in the Natural Resource Management and Product Development areas (though both account for less than 10% of funds). Competitive Grants to Consumer Health & Nutrition fell from 16.5% of funds in 1983 to about 7% in 1997. Special Grants have a distinctly different mix from Competitive Grants. The leading categories in terms of research funds are Pest and Disease Protection (21%) and research to improve communities and the environment (almost 18%). Special Grants devote a higher percentage of their funds to community and environmental research than any of the four instruments (figure 4). Most of these funds are used for research on pollution alleviation and fish and wildlife. Generally, Special Grants became more evenly distributed among the research goals from 1983-1997. Production-related research, product development and consumer health and nutrition remained priorities for special grants in both 1983 and 1997. While funds to consumer research declined slightly in 1997, Special Grants still allocate a greater percentage of research resources to this goal. For Cooperative agreements, which represent funds from USDA research agencies, the highest priorities are research on Pest and Disease Protection (24% of funds), Natural Resource Management (22%), and Production-related research (almost 19%) (figure 5). Cooperative agreements devoted the greatest portion of their funds of any of the four instruments to Natural Resource Management (almost 14%), and this increased over time.

While the resources devoted to these research goals indicate some differences in uses of these instruments, the broad nature of the goals mute some of the nuances of these differences. For example, within production related research, over a third of Competitive Grants went to "Non-Commodity-Oriented Biological Technology and Biometry." This research problem area tends to capture very basic research, and was a much greater priority for Competitive Grants than for the other three funding mechanisms. Thus, Competitive Grant funding appears to have been concentrated in areas with high potential spillover effects.

Concentration of research funds

The distribution of funding among the different states is of interest as well. Some applied research may have a public good component, and therefore be performed by public sector institutions. Applied research addresses needs that may be location-specific, therefore the benefits may accrue primarily to that location. In other words, such research produces local rather than global public goods. Aspects of agricultural production can be regional in nature. Therefore, research conducted on production methods in the Southwest, for example, may have greater benefits for farmers in that region than for farmers in the Northeast. Likewise, certain environmental issues may be regional in nature, such as the use of Western water resources. Consumer health and nutrition is another issue where applied research concerns can vary geographically (e.g., research on access to fresh produce.) Therefore, we wanted to assess the division of applied research funding among State-level institutions.

To evaluate the distribution of funds going to states via these four instruments, we used three concentration measures: the Herfindahl Index, the Gini Coefficient, and the Four State Measure. The Herfindahl Index and the Gini Coefficient illustrate the concentration over the entire distribution of funds, while the Four State Measure highlights the extent of concentration of funding among the top four states under each funding source. We calculated these three measures of concentration for formula funds, NRI, special grants, and cooperative agreements for fiscal years 1983, 1987, 1993, and 1997.

The Herfindahl Index is given by:

$$H_{nt} = \sum_{i=1}^{n} S_{it}^{2}$$

where H_{nt} is the Herfindahl Index value for the set of states, n, in year t and S_{it} refers to the share (percentage) of funding going to state i at time t. A Herfindahl Index value of 204 represents complete equality of funding across the set of 49 states used in the analysis. The greater the inequality in the funding distribution, the larger the index value.

Table 1 gives the Herfindahl index for four years within the period reviewed. In each year, Formula Funds are the least concentrated of any funding mechanism. In contrast, Competitive Grants are the most highly concentrated instrument for each year. Special Grants are less concentrated than Competitive Grants, but more concentrated than the Cooperative Agreements used by USDA research agencies.

The Gini Coefficient is given by:

$$G_{nt} = 1 + \frac{1}{n} - \frac{2}{(n^2 S_t)}(S_{1t} + 2S_{2t} + \ldots + nS_{nt})$$

where G_{nt} is the Gini Coefficient for the set of states, n, in year t, S_{it} represents the average share for n states, and S_{it} refers to the share (percentage) of funding going to state i at time t. To appropriately calculate this statistic, the shares must be ranked in descending order such that $S_1 \geq S_2 \geq S_3 ... \geq S_n$. A Gini Coefficient value of 0 represents complete equality of funding across this set of states. The greater the inequality in the funding distribution, the larger the coefficient.

The Gini Coefficients for each funding instrument can be found in Table 1. Because there are zero values in certain categories for some States, the results differ slightly from the Herfindahl indices. Competitive Grants remain the most concentrated of the funding measures, except in 1997. Compared with the Herfindahl indices, the Gini coefficients indicate higher degrees of concentration for both Special Grants and Cooperative Agreements from USDA. Formula Funds clearly remain the least concentrated of the four instruments. However, there are changes over time within the Gini Coefficients. Notably, Formula Funds appear to be slightly more concentrated as time goes by. On the other hand, Competitive Grants appear to be growing less concentrated over time. (These trends are not seen in the Herfindahl indices).

The Four State measure gives some sense of the concentration among the highest echelon of funding recipients.

The Four State Measure is given by:

$$F_{nt} = \sum_{i=1}^{4} S_{it}$$

where F_{nt} is the Four State Measure for the set of states, n, in year t and S_{it} refers to the share (percentage) of funding going to state i at time t. Again, the shares must be ranked in descending order such that $S_1 \geq S_2 \geq S_3 ... \geq S_n$. A Four State Measure value of 8.2% represents complete equality of funding across this set of states. The greater the concentration in the funding distribution, the larger the measure. As shown in table 1, Formula Funds are the least concentrated of the these four mechanisms. In 1997, the top four states received 16% of Formula Funds. Similar to the Gini Coefficient, there appears to be a slight increase in the concentration of Formula Funds among the top four states over time. Generally, the Four State measure shows the greatest degree of concentration for Competitive Grants. However, in 1997, we see concentration among Special Grants virtually equal to that of the Competitive Grants. Otherwise, the measure does not indicate consistently declining concentration among the top four recipients of Competitive Grants.

States' Level of Dependence on Different Funding Instruments

Table 2 ranks states according to their dependence on the four funding instruments. The first column lists states, and the percentage of their research funds that come from competitive grants.[5] In general, states' dependence on competitive grants vary. Nine states rely on competitive grants for over 20% of their research funds, and three states get over 35% of funds

[5] "Research funds" refers to the total funds received by each of the 49 states from the four instruments being reviewed, not the state's total amount of agricultural R&D funding.

from competitive grants. However, the greatest diversity in reliance is found with Cooperative Agreements (column 4). Almost 60% of Colorado's funds are awarded through contracts, grants and agreements with USDA research agencies. Five other states receive over 40% of funds through this mechanism. The reliance on Congressionally-awarded Special Grants more closely resembles that of Competitive Grants (column 3). Special grants account for more than 20% of funds from these mechanisms for 11 states (North Dakota, Washington, Michigan and Hawaii being the four most dependent states). Of course, most states rely on Formula Funds, the largest source of USDA research resources allocated to the states (column 2). Formula Funds account for at least 50% of the funds from these mechanisms for 29 of the States. Many states rely almost exclusively on formula funds. Finally, this discussion focuses on the relative importance of the different funding mechanisms for individual states, therefore it does not account for magnitude. Some states with significant agricultural populations, such as New York, receive substantial Formula Funds, even though their reliance on Formula Funds may not be high.

Regression Analysis

To explain the distribution of NRI competitive grants, we compiled several variables that describe a state's capacity to attract these research funds.   In assembling our regression model, we first hypothesized competitive grant funding would favor states with strong academic programs in frontier biological sciences and agricultural sciences, based on Buttel and Evenson. Second, the congruence or parity (Ruttan, 1982) model of research resource allocation suggests that funding for research activities might be expected to be proportional to the relative importance of a commodity. Thus, we include the market value of agricultural products in a state as a means of measuring the degree to which competitive grants go to "major" agricultural states. This variable allows us to examine congruence as a predictor of competitive funding. Third, Evenson has suggested that research spillovers would be higher from more productive states than those with lower productivity. One of the goals of competitive grants is to increase overall U.S. research productivity, rather than focussing narrowly on productivity gains in a single region or crop. One might then expect funding to be allocated to states which could have the highest spillover impacts on other regions. One might also expect research to be directed to *research areas* with higher spillover effects. Moreover, Craig and Pardey (1989) found that productivity and research funding were mutually reinforcing. Thus we hypothesize a relationship between productivity and competitive research funding, though the causation is not necessarily uni-directional. In different regression models, we used several different multi-factor productivity and efficiency measures as proxies for the "productivity" of a state's agriculture. Finally, grants may be allocated more to states with greater complementary human resources (i.e., agricultural scientists), in part because of the nature of the research production function, and in part because larger numbers of agricultural scientists should be associated with more grant seeking efforts (Huffman and Just).

We drew the data on state agricultural marketings from the agricultural income data base maintained by the Economic Research Service.[6] To assess the characteristics of the states' research institutions, we developed measures based on rankings of graduate programs from the National Research Council (1997) and the Gourman Report (1988). First, we created five

[6] Found at <http://www.ERS.USDA.gov/ briefing/ farmincome/finfidmu.htm>.

dummy variables summarizing the rankings of any of three different types of biology programs at any universities within a state among the top 50 nationwide (see appendix table for variable descriptions). Second, we created four dummy variables based on the Gourman Report ranking of agricultural science programs at institutions within each state. Multifactor productivity indicators were calculated based on data presented by Huffman and Evenson (1993) and Ball *et al.* (1999), and efficiency measures were taken from O'Donnell (2000).[7] Finally, we incorporated Huffman and Just's (1994) data on the number of Ph.D. scientists in each state. With the exception of the marketing data and one multifactor productivity measure, these explanatory variables, for each state, are constant through time.

All these variables generated a panel data set across fifteen fiscal years and 49 states.[8] To identify the factors associated with the allocation of competitive grants, we conducted a regression analysis on the panel data set, estimating a one-way random effects model with a feasible generalized least squares approach. The model assumed that for a given year, the disturbances for different states were correlated. The model assesses the relationship between the percentage of competitive grants funding received by a state in a year and the set of independent variables for that state. (Again, see appendix table for list of all variables tested).

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7 O'Donnell (2000) estimated the technical efficiency measure using a system of equations derived from a translog shadow cost frontier for agriculture in the lower 48 states.

8 While the *Inventory of Agricultural Research* does provide data on Alaska, Washington, DC, and the territories (American Samoa, Guam, Northern Marianas, Puerto Rico, and the Virgin Islands), these entities fell out of our analysis because of missing data in several of the explanatory variables. For example, Huffman and Just did not supply the number of Ph.D. scientists for Alaska. Further, *Agricultural Statistics* does not publish marketing estimates for Washington, DC and the territories. For the regression results reported below, Hawaii is also excluded. In some models not presented here, the New England states were excluded as well. In other cases, we used all 49 states in the data set. Even our most restrictive subsample of 42 states represented nearly 98% of all agricultural marketings in the U.S. in 1997.

Results

Regression results suggest that states with relatively strong agricultural sectors and with greater numbers of Ph.D.-level scientists receive higher percentages of the total amount of competitive grant funding received in a given year. States with greater technical efficiency in agriculture also receive larger proportions of total competitive grant funding, but results across models using different efficiency measures were somewhat less robust than the first finding. In the results reported in Table 3, as well as in other models, the set of dummies ranking the perceived strengths of biology and genetics programs at all universities within a state, as well as the set of dummies ranking the strengths of agricultural science programs, were highly significant indicators of a state's ability to obtain competitive grant funding. However coefficients of individual variables suggest that a biology department must fall within the top 20 or 30 rankings, and an agricultural science program must be ranked in the top 10, in order for a State to significantly improve its chances of obtaining competitive grants.

Qualitative results do not differ significantly with the inclusion of different sets of states in the regressions. However, coefficient estimates generally were larger in relation to standard errors for agricultural marketing and biology department ranking variables in models in which the New England states and Hawaii were omitted. This suggests that the different characteristics of agriculture and the agricultural research systems in these smaller producers might dilute, if only slightly, the predictive power of the regression model.

Conclusions

The descriptive statistics we developed indicate that the four funding instruments have emphasized different research categories. Our analysis of research funding patterns suggests that the R&D funded by competitive grants is indeed more basic than that funded by other instruments. Basic biological and biotechnology research was a leading research area. We also noted that, generally, R&D funded by competitive grants is concentrated among fewer states.

Nonetheless, the distribution of overall USDA research funds to states has *not* changed in terms of research emphasis or geographic distribution. This is for two reasons: (a) competitive grants still comprise only 15% of these funds and (b) the resource allocations found in the other funding instruments seem to have counteracted some of the trends in competitive grant funding.

After 20 years of competitive grant funding, overall funding patterns still mirror the pattern found in formula funds. However, since many states rely heavily on formula funds as a source of support, however, large-scale reallocation of federal funds from other programs to competitive grants may have a much more profound impact on research patterns and geographic dispersion than has been felt to date. States with large agricultural production and top ranked academic programs in biology and agricultural sciences would probably receive larger shares of Federal funding than at present. The impacts of such a shift on agricultural productivity have yet to be assessed.

Table 1. Concentration measures

Herfindahl Index for different funding mechanisms
(parity = 204.08)

	Formula Funds	Cooperative Agreements	Special Grants	Competitive Grants
1983	249.08	408.75	430.99	473.94
1987	253.59	378.83	451.94	530.87
1993	256.09	362.78	398.51	472.08
1997	255.98	382.06	436.02	439.39

Gini Coefficients for different funding mechanisms
(parity = 0)

	Formula Funds	Cooperative Agreements	Special Grants	Competitive Grants
1983	0.2667	0.5208	0.4931	0.5562
1987	0.2790	0.5117	0.5576	0.5593
1993	0.2858	0.4716	0.5163	0.5186
1997	0.2856	0.4893	0.5502	0.5043

Four State measures for different funding mechanisms
(parity = 8.16%)

	Formula Funds	Cooperative Agreements	Special Grants	Competitive Grants
1983	15.47%	27.18%	30.55%	30.97%
1987	15.79%	23.97%	30.04%	33.81%
1993	16.00%	25.32%	26.42%	34.29%
1997	16.01%	26.51%	30.07%	30.06%

Table 2. States' dependence on different funding mechanisms

Competitive Grants		Formula Funds		Special Grants		Coop Agreements	
	% of funds		% of funds		% of funds		% of funds
NJ	38.99	NH	91.20	ND	38.94	CO	59.75
CA	37.22	KY	85.34	WA	35.43	UT	55.55
WI	36.59	WY	84.21	MI	33.27	MS	45.78
MA	28.08	SD	79.18	HI	31.89	AZ	43.46
PA	25.58	TN	78.99	NM	25.83	ID	42.41
NY	24.90	WV	78.67	OR	25.60	VT	40.41
IL	23.69	RI	77.53	ME	25.48	IN	39.48
CT	23.61	AL	71.96	IA	24.01	OR	35.23
AZ	22.45	OH	70.73	FL	23.53	VA	31.01
MN	19.71	LA	69.39	OK	23.22	AR	29.04
NE	19.22	DE	66.94	NY	22.22	HI	28.97
RI	19.22	NV	66.01	NJ	18.87	NM	27.88
FL	19.12	SC	65.84	KS	18.76	TX	27.86
MI	18.94	GA	64.64	MO	16.26	MD	26.85
MT	17.79	VA	62.72	NE	16.14	NE	26.45
NV	17.65	PA	59.97	MS	15.47	MT	25.04
DE	16.79	VT	59.59	AR	14.48	SC	23.89
NC	16.37	NC	58.32	CA	14.44	WA	23.10
KS	16.35	CT	57.78	AL	14.26	CA	22.71
MO	16.18	MA	57.17	IL	12.39	MN	20.19
OR	16.08	OK	57.00	MT	11.87	GA	19.38
ND	15.80	IL	56.65	TX	10.99	NC	19.31
TX	15.44	IA	54.38	PA	10.44	NY	19.10
WA	14.02	KS	53.97	CT	8.94	LA	18.54
IN	13.94	AR	52.77	WI	8.61	FL	17.76
IA	13.76	ME	52.42	MN	7.96	DE	16.27
OH	13.37	MD	52.38	OH	7.57	MO	15.73
MD	13.23	MN	52.14	MD	7.55	ME	14.30
TN	12.83	MO	51.84	GA	6.62	WV	13.25
SD	11.33	TX	45.70	NC	6.00	NV	13.07
OK	10.67	MT	45.30	SC	5.87	MI	11.60
HI	10.45	IN	45.16	KY	5.83	KS	10.92
GA	9.35	WI	44.26	ID	5.55	MA	10.58
NH	8.80	ID	43.33	AZ	5.45	WI	10.53
ID	8.70	NM	43.22	LA	4.86	CT	9.68
ME	7.79	NJ	39.60	SD	4.21	ND	9.37
WY	7.74	FL	39.60	MA	4.17	AL	9.25
WV	7.69	NE	38.18	VA	3.54	OK	9.10
LA	7.22	MI	36.19	TN	3.51	OH	8.33
UT	6.99	MS	35.91	NV	3.27	WY	8.05
CO	6.88	ND	35.89	RI	3.25	IA	7.85
AL	4.53	UT	35.80	UT	1.67	IL	7.28
SC	4.41	NY	33.78	IN	1.41	KY	6.38
AR	3.71	CO	32.23	CO	1.14	SD	5.29
NM	3.07	HI	28.68	WV	0.40	TN	4.66
MS	2.83	AZ	28.65	WY	0.00	PA	4.01
VA	2.73	WA	27.44	NH	0.00	NJ	2.53
KY	2.45	CA	25.63	DE	0.00	RI	0.00
VT	0.00	OR	23.09	VT	0.00	NH	0.00

Table 3: Factors Influencing Percent of Competitive Grants Funds Received by Each State

Variable	Coefficient
Agricultural Marketings as a Percent of Total Agricultural Marketings	0.109 (0.0434)***
Top 10 Biology Department, 1997 NRC Rankings	1.962 (0.177)***
Second 10 Biology Department, 1997 NRC Rankings	0.298 (0.164)**
Third 10 Biology Department, 1997 NRC Rankings	0.292 (0.220)*
Fourth 10 Biology Department, 1997 NRC Rankings	-0.648 (0.230) ns
Fifth 10 Biology Department, 1997 NRC Rankings	-0.987 (0.188) ns
Top 10 Agricultural Sciences Program, Gourman Rankings	0.917 (0.221) ***
Second 10 Agricultural Sciences Program, Gourman Rankings	-0.173 (0.161) ns
Third 10 Agricultural Sciences Program, Gourman Rankings	0.00850 (0.161) ns
Fourth 10 Agricultural Sciences Program, Gourman Rankings	-0.914 (0.262) ns
Ph.D.'s	0.00956 (0.000594) ***
Technical Efficiency	0.925 (0.468) **
Constant	-1.284 (0.259) +++

R^2: 0.778
n = 720
F-statistic, H_0: all biology ranking coefficients = 0.   F(5,707) = 59.373; p=0.000
F-statistic, H_0: all agricultural sciences ranking coefficients = 0. F(4,707) = 13.832; p=0.000
Figures in parentheses are standard errors.
*   Significant at 10% level, one-tailed test
**   Significant at 5% level, one-tailed test
***   Significant at 1% level, one-tailed test
+++   Significant at 1% level, two-tailed test

Figure 1

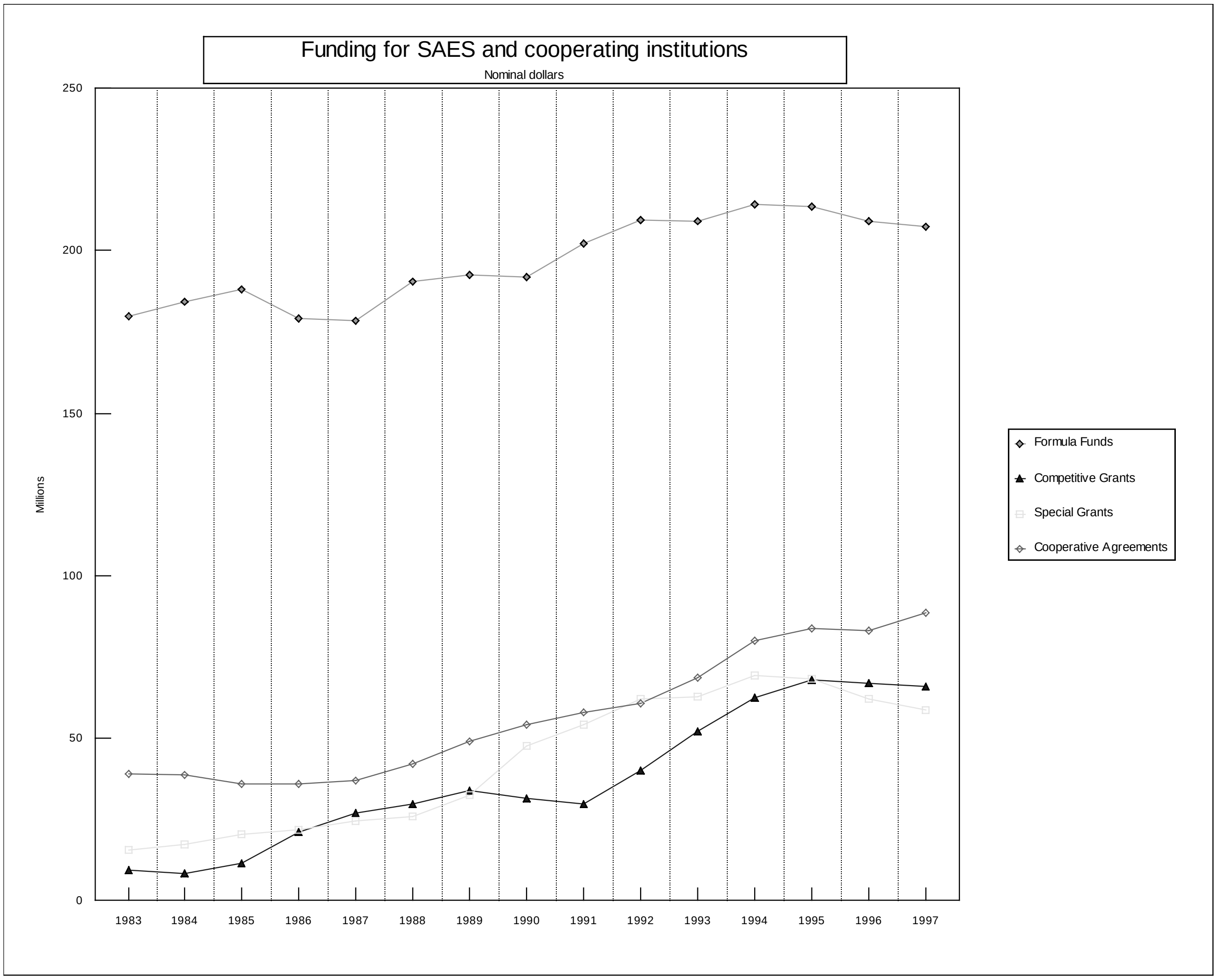

Funding for SAES and cooperating institutions
Nominal dollars
Millions
0
50
100
150
200
250
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
Formula Funds
Competitive Grants
Special Grants
Cooperative Agreements

Figure 2

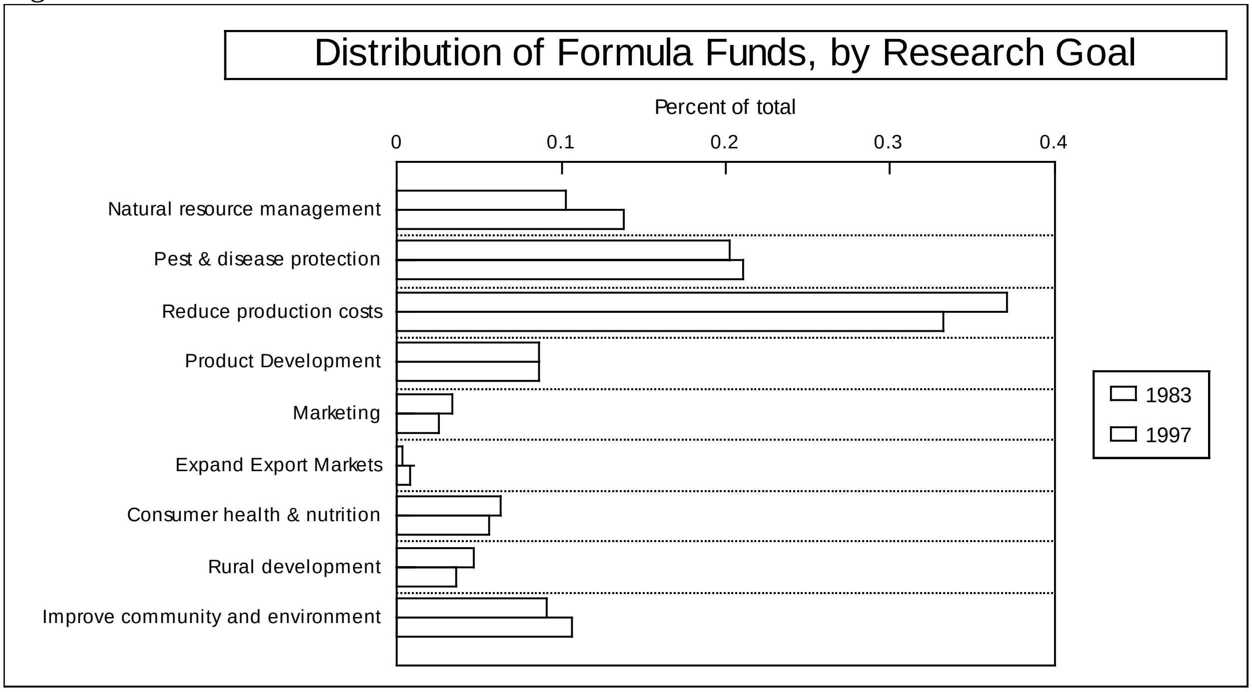

Distribution of Formula Funds, by Research Goal
Percent of total
0
0.1
0.2
0.3
0.4
Natural resource management
Pest & disease protection
Reduce production costs
Product Development
Marketing
Expand Export Markets
Consumer health & nutrition
Rural development
Improve community and environment
1983
1997

Figure 3

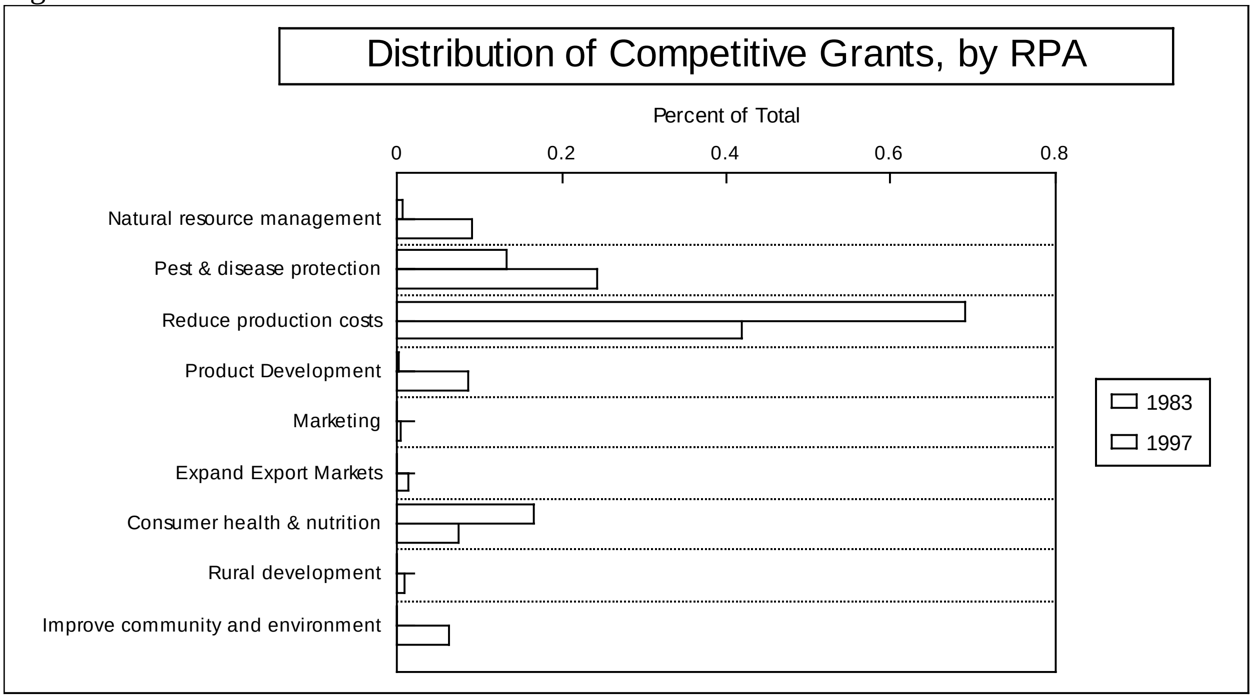
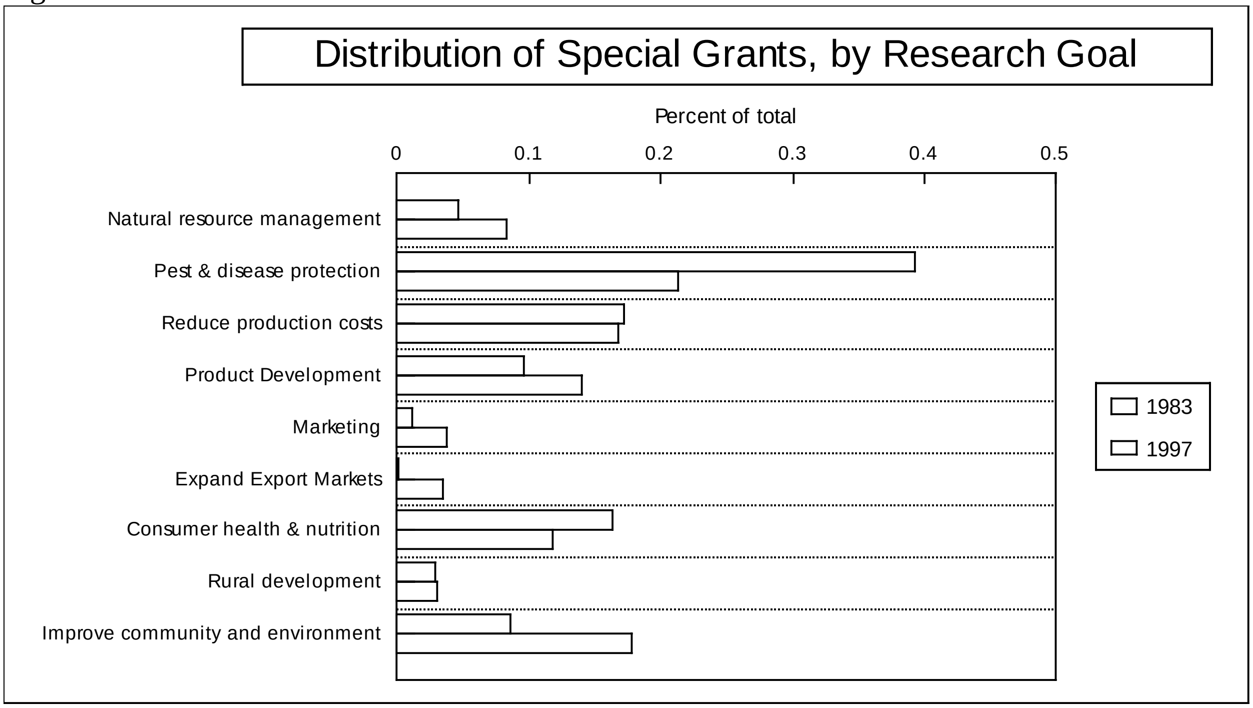
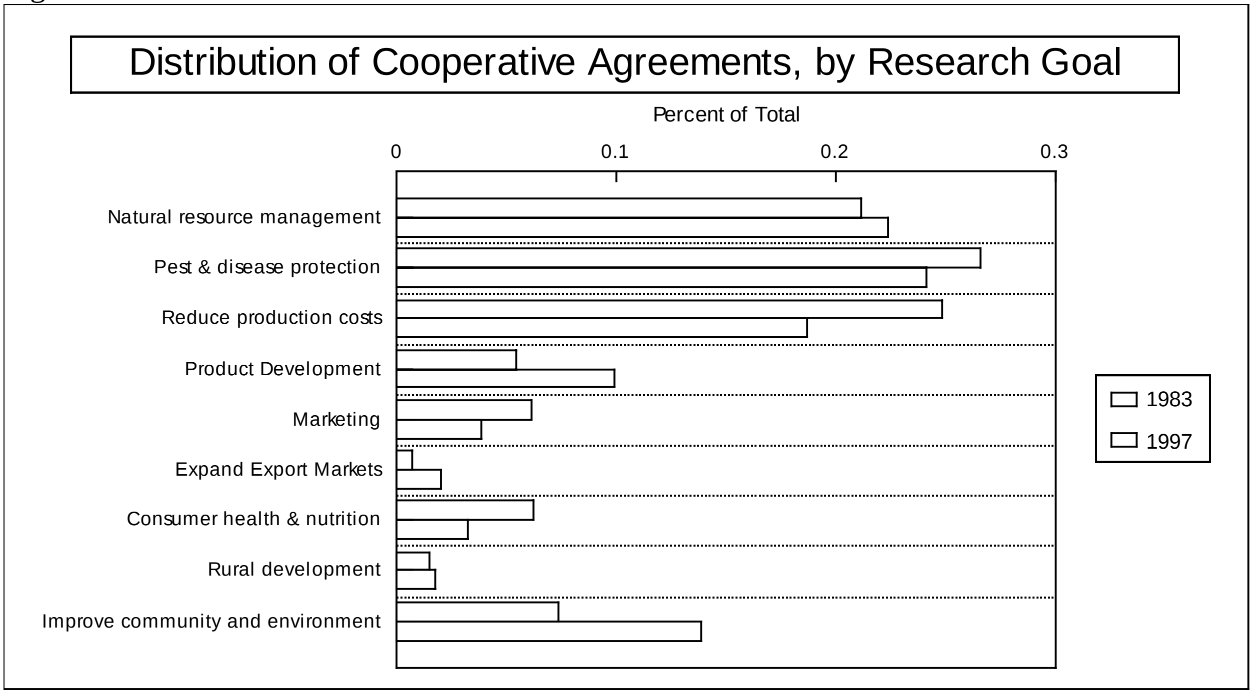

Distribution of Competitive Grants, by RPA
Percent of Total
0
0.2
0.4
0.6
0.8
Natural resource management
Pest & disease protection
Reduce production costs
Product Development
Marketing
Expand Export Markets
Consumer health & nutrition
Rural development
Improve community and environment
1983
1997

Figure 4



Distribution of Special Grants, by Research Goal
Percent of total
0
0.1
0.2
0.3
0.4
0.5
Natural resource management
Pest & disease protection
Reduce production costs
Product Development
Marketing
Expand Export Markets
Consumer health & nutrition
Rural development
Improve community and environment
1983
1997

Figure 5



Appendix Table: Data tested in various regression models

Independent variable:
percomp: state competitive grants as percentage of total competitive grants in a year.

Dependent variables:
permktag: state ag marketings as a percentage of total ag marketings in a year.

mfpag: State agricultural multifactor productivity in 1982. Mfpag is calculated by assuming Huffman and Evenson's "Efficiency Index" 1950 refers to the level of state agricultural multifactor productivity in 1950, and that MFP grew from that level at the rates indicated. Huffman and Evenson p. 199.

mfpagheb: Year-by-year state multifactor productivity in agriculture. Begins with the same level in 1950 as mfpag, and assumes state agricultural multifactor productivity grew at the rates indicated by Huffman and Evenson until 1960. From 1960 to 1996, each year state agricultural multifactor productivity is assumed to change by the amount calculated by Ball *et al*. Since the data presented by Ball *et al*. ends in 1996, the 1997 figure is calculated by assuming that MFP in 1997 grew from 1996 at the average rate for 1989-1996.

efftech: measure of relative technical efficiency due to O'Donnell (2000), who applied parametric estimation to the state data developed by Ball *et al*.

effcost: measure of relative cost efficiency due to O'Donnell (2000), who applied parametric estimation to the state data developed by Ball *et al*.

cbioall dummies, based on rankings found in Gourman (1988)
cbioall1= 1 if molecular/cell biology program at any university ranks in the top 10, 0 otherwise.
cbioall2 = 1 if molecular/cell biology program at any university ranks 11-20, 0 otherwise.
cbioall3 = 1 if molecular/cell biology program at any university ranks 21-30, 0 otherwise.
cbioall4 = 1 if molecular/cell biology program at any university ranks 31-40, 0 otherwise.
cbioall5 = 1 if molecular/cell biology program at any university ranks 41-42, 0 otherwise.

agsci dummies, based on rankings found in Gourman (1988)
agsci1 = 1 if agricultural science program ranks in the top 10, 0 otherwise.
agsci2 = 1 if agricultural science program ranks 11-20, 0 otherwise.
agsci3 = 1 if agricultural science program ranks 21-30, 0 otherwise.
agsci4 = 1 if agricultural science program ranks in 31-32, 0 otherwise.

nrcbioa dummies: Reflects rankings of any of three types of biology programs (molecular and general genetics; cell/developmental biology; and biochemistry/molecular biology) at any university within a State. All are from the NRC rankings (1997).[9]

nrcbioa1 = 1 if any biology program at any university ranks in the top 10, 0 otherwise.
nrcbioa2 = 1 if any biology program at any university ranks 11-20, 0 otherwise.
nrcbioa3 = 1 if any biology program at any university ranks 21-30, 0 otherwise.
nrcbioa4 = 1 if any biology program at any university ranks 31-40, 0 otherwise.
nrcbioa5 = 1 if any biology program at any university ranks 41-50, 0 otherwise.

nrcbiol dummies: Reflects rankings of any of three types of biology programs (molecular and general genetics; cell/developmental biology; and biochemistry/molecular biology) at a Land Grant University within a State. All are from the NRC rankings (1997).[10]

nrcbiol1 = 1 if any biology program at a land grant university ranks in the top 10, 0 otherwise.
nrcbiol2 = 1 if any biology program at a land grant university ranks 11-20, 0 otherwise.
nrcbiol3 = 1 if any biology program at a land grant university ranks 21-30, 0 otherwise.

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[9] For example, if a state has an institution in the top 10, and another in 21-30, only its top institution(s) get coded. However if a state has a non-land grant institution in the top 10, and a land grant institution in 21-30, the "all" variable would reflect the first fact, and the "land grant" variable would reflect the second.

[10] See footnote 9.

nrcbiol4 = 1 if any biology program at a land grant university ranks 31-40, 0 otherwise.
nrcbiol5 = 1 if any biology program at a land grant university ranks 41-50, 0 otherwise.

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