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FEDERALISM, REAPPORTIONMENT AND INNOVATION:
THE CASE OF AGRICULTURAL RESEARCH AND EXTENSION

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ABSTRACT

Federalism, Reapportionment and Innovation: The Case of Agricultural Research and Extension

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This paper seeks to identify the economic and political factors that produce state financial support for agricultural research and extension. We hypothesize that the state demand for research and extension services is influenced not only by an interest in generating social benefits but also by the size and political effectiveness of farm interests and by the federal structure of government. Although basic measures of farm income and population are a key determinant of spending patterns, measures of intergovernmental influence are also empirically important. Federal grants have "price" effects which stimulate spending; the reapportionment of state legislatures mandated by the U.S. Supreme Court had a negative effect, while the ability of farmers to elect other farmers to the legislature raises state support for research and extension. In general, we conclude that given current trends in political and economic conditions, the downward trend in the relative importance of agricultural R and D spending appears likely to continue in spite of the high marginal rate of return to such research.

I. Introduction

Empirical studies of the rate of return to publicly supported agricultural research and extension show consistently high rates, generally above 20% per year.[1] These results prompt an economist to ask why the investment is not higher. State and federal governments do not appear to be maximizing the sum of producers' and consumers' surplus. We hypothesize, instead, that the demand for research and extension services is influenced not only by an interest in generating social benefits but also by the size and political effectiveness of farm interests and by the federal structure of government.[2]. While the supply of research and extension services may depend on the prices of human and other resources and on the stock of potentially worthwhile ideas, it is also determined by the availability of federal grants and of spill-in technology. In addition state spending may be affected by laws and court decisions at the national level which preempt state choices and affect the balance of political influence within a state. The major example here is the reapportionment of state legislatures mandated by the Supreme Court in 1962. This judicial decision is widely believed to have reduced the relative influence of farm and rural interests. Our research is an advance over work which looks separately at any one of these influences. For example, research on reapportionment has seldom directly studied programs of interest to farmers and has not assessed the impact of federal grants (see Saffell, 1982, 204-210). Conversely, research on federal grants has not been concerned with the impact of reapportionment on state spending decisions (see e.g., Gramlich, 1977).

Section II of the paper lays out the basic conceptual framework and discusses our data base. Section III presents the research findings. We show that the overall importance of farming to a state measured both in terms of income and population partially determines spending patterns. However, political structure and federal grants also influence budgetary decisions. We find that the reapportionment in the 1960s, which reduced rural "over-representation," had a negative effect on state support for research and extension spending. We also find that Federal grants play an independent role in affecting state spending. Although federal grants have no real marginal price effect in most states, budget setters act as if grants reduce the marginal cost of services. In addition, if farmers are able to elect other farmers to the legislature,this is associated with higher levels of state support for agricultural research and extension. Finally, "spill-ins" of research results from other states appear to have a negative effect on livestock research but are unimportant for crop research.

II. The Basic Framework

A. The Interests of Farmers and Consumers

Most agricultural technology lowers costs and shifts supply curves rightward. With easy entry and few specialized factors, prices tend to fall with average costs (Hayami and Ruttan, 1975; Evenson, 1982: Binswanger and Ruttan, 1978). This suggests that, so long as promising research projects are available, consumers should be the major interest group supporting research and extension and implies that they would lobby for federal rather than state support. It appears, however, that consumer groups are relatively weak supporters of research and extension at both the state and federal level.[3]

In contrast, farm producer groups actively lobby state governments for research and extension funds. This behavior ceases to be anomalous once one recognizes that most agricultural technology produced by public sector experiment stations can only be used under certain geoclimatic conditions. Many crops which are close substitutes for consumers are grown under very different supply conditions. Research which improves the productivity of Hard Red Spring wheat grown in Minnesota, for example, may be of little or no use to Hard Red Winter wheat farmers in Oklahoma. Farm groups in a particular state with localized growing conditions may thus earn "rent" by supporting research and extension. This will be the case if a state's farmers provide only a small share of total market output and if their growing conditions are very idiosyncratic. Of course, the rent will be eroded by the research and extension support programs of other states, but the erosion is independent of the state's own investment.[4]

The location specificity of agricultural technology is, however, not neatly associated with state political boundaries. Most new technology produced by a particular state will "spill-in" to other states with similar soil and climate conditions. Thus "free-riding" is possible for producer groups in states which receive technology from outside (cf. Ruttan, 1982a). It is not obvious, however, that spill-ins will reduce the demand for state supported research. Although direct transfers are possible in some cases, in other situations the borrowed research is not useful unless it has been incorporated into the state's own research program and adapted to local conditions. To capture these effects for each state we have measures of the investment in research by states in similar geoclimatic region based on work done by Evenson (1978). We calculated separate spill-in measures for crops (SPCROP) and livestock (SPLVSTK). (See Appendix 1 for detailed definitions.)

In short, the multiplicity of state governments combined with variable geoclimatic conditions helps to explain farmers' support for research and extension. While some borrowing is possible and may work to reduce support, we hypothesize that it will not outweigh farmers' other interests in higher state research budgets. This is especially likely to be so because farmers do not directly bear much of the cost of financing the state experiment stations and the extension service.

B. Empirical Specification

1. Dependent Variables

We do not believe that it is possible to develop a plausible model of state politics in which "the government" maximizes a utility function subject to constraints or makes majoritarian choices reflecting the preferences of the median voter. The political system is simply too complex to be captured in this way. We do, however, believe that a range of exogenous political economic variables will have a marginal impact on the share of a state's budget spent on agricultural research and extension.[5] We proceed, therefore, to specify reduced form relationships between measures of state spending, treated here as endogenously determined by states, and several economic and political variables that affect supply and demand. In this section the motivation for including each variable is explained. They are defined precisely in Appendix 1 which also reports their means and standard deviations.

We examine research and extension spending separately. Budgetary choices may differ for these two related programs because the political support for each is somewhat different and because separate federal subsidies cover each program. Research projects, involving the search for new crop varieties and production techniques, may take several years to produce useful results. Therefore, research may be most strongly supported by relatively large farmers with a considerable capital investment and a long-term perspective. Such farmers may have less demand for public extension service if they are highly skilled managers and large purchasers of private extension services. In contrast, the public extension services which disseminate research results to farmers may be of relatively greater benefit to smaller, poorer farmers. Therefore, we expect that farm income will be relatively strongly associated with research while farm population will be more strongly associated with extension.

We use state data for the agricultural census years 1959, 1964, 1969, 1974 and 1978 and estimate two related specifications for research spending and for extension spending. The first takes total state appropriations as a share of the budget as the dependent variable (STRS/SB and STEXT/SB for research and extension respectively). This specification assumes that states choose a level of overall appropriations on the basis of state economic and political characteristics and federal grants. The second attempts to explain excess state spending over the amount required to match federal grants

(XSTRS/SB and XSTEXT/SB for research and extension). This second formulation assumes that state political choices focus on spending not required for matching purposes.

To see how the two types of dependent variables are related, suppose that an increase in federal grants of one dollar induces an increase of 75 cents in state appropriations. Suppose that the matching rate is 50% so that every dollar of federal money must be matched by a dollar of state money. Then if total state appropriations increase by 75 cents, excess spending, not required to satisfy matching requirements, falls by 25 cents. In making our estimates we impose this restriction on the federal grant coefficients.

We make a moderately strong assumption about the link between spending on research and extension and the total state budget. The dependent variables are defined as shares of the total state budget. Since total state spending is closely related to state income, we include total personal income of the state (TPY) as an independent variable. We hypothesize that the share of the budget expended on agricultural research and extension is related to a set of economic and political variables and to the total personal income of the state. However, the overall budget is assumed to be more income elastic than appropriations for agricultural R and D. Thus an increase in state income should reduce the budget share of agricultural research and extension.

2. Farm Income and Population Variables

We expect that states with higher farm income and population shares (NFY/TPY and FPOP/TPOP respectively) will spend a higher proportion of their budgets for both research and extension. The interpretation of a significant positive coefficiant is difficult, however. Ceteris paribus the benefits to a state of its agricultural research and extension activity will be larger if farm income and population are high. Alternatively, if farmers are an important source of a state's income and a substantial fraction of the population, we might expect them to be an effective political force capable of obtaining high levels of public research and extension spending. The relative size of the farm population is a proxy for their voting strength. Farm income, through campaign contributions and other favors, may also translate into political influence.

3. Measures of Farmers' Political Influence

Although we have not been able to examine the explicit mechanisms by which farm income and population affect research and extension spending, we have tried to capture farmers' political influence more carefully than previous work. We were aided in this effort by the availability of data stretching back to 1958 and by an important structural change in state political systems that occurred during the 1960s. In 1962 the U.S. Supreme Court in Baker v. Carr, 369 U.S. 186, 226 (1962), decided that both houses of a state's legislature must be apportioned so that each district contained approximately the same number of voters. Before this decision went into effect as few as 12% of the voters in some states could elect 50% of the members of one house of the State legislature.[6] When this proportion is low, rural voters are generally overrepresented in the legislature. By the end of the sixties about 50% of the population was needed to elect 50% of the legislature in all states.[7] Thus the Supreme Court decision makes it possible to distinguish between political power determined by numbers and wealth irrespective of the particular structure of the political system and influence that depends upon favorable institutional arrangements. We have two ways to capture the impact of reapportionment. First of all we have a measure of the share of the population needed to control the state legislature (PCNTC). Second, since the reapportionment decision occurred in the middle of our data set, we can see whether rural overrepresentation aided farm interests in the earlier period. Thus, we have defined a dummy variable (APP) which equals one if a data point is from the post-apportionment period and zero otherwise. We interact this dummy with both the farm income and population variables and expect that for the post-apportionment period population will have more influence and income less.

For the most recent years we have another explicitly political variable: the proportion of legislators who list farming as their occupation (PCFRMR). The proportion ranged from 0 to 47% in 1975 with a mean of 10.4% (Insurance Information Institute, 1976). Of course, a simple vote maximizing model of politicians' behavior implies that a person's occupation ought to be irrelevant to the policies he or she espouses. Legislators simply vote in the way that will maximize their chance of reelection. However, if one assumes that voters do not take much time to find out about candidates' positions, then occupation may be important. Voters might suppose that if a candidate is labeled a "farmer", he will look out for farmers' interests better than a lawyer or an insurance agent. Occupational classification is a kind of signal to voters indicating the candidate's policy positions. If this view is plausible, the proportion of legislators who are farmers is a measure of farmers' ability to elect people to state office who are willing to work for agricultural interests. Since we would expect PCFRMR to depend on the proportion of farm income and farm population in a state, we regressed PCFRMR on NFT/TPY and FPOP/TPOP for the 1969-74-78 data sets and entered the residual in the regressions (RESFMRS).[8]

We also have one measure of farmers' organizing ability: membership in marketing coops divided by the number of commercial farms (MCOOP). Farmers, already organized to market their products, might use these cooperatives to lobby public officials. This variable may not, however, be a purely political measure. A strong cooperative movement in a state may also facilitate the introduction of new technology and thus increase the benefits of research.

Finally, some work by political scientists suggests that the civil war left the southern states with a different political structure and culture than the rest of the country. Thus some empirical work on state politics includes a dummy variable for the southern states to take account of these differences. This, of course, amounts to an admission of ignorance. If one understood why the south is special, one could capture these distinctive characteristics explicitly. To find out if we too have omitted important southern regional characteristics we also include a southern dummy variable (SOUTH). Product mix might, however, be more important than region. Perhaps crop farmers are on balance a more effective political force than livestock farmers. Thus we include a variable measuring the share of agricultural output accounted for by crops (CSHARE).

4. Intergovernmental Grants

Subtle interstate differences in political structure and marginal benefits may, however, be swamped by the overwhelming effect of Federal grant programs. Thus we include measures of Federal grants as a share of the total state budget (FEDRS/SB and FEDEXT/SB for research and extension respectively).

Federal funds are important, accounting for between one quarter and one third of total research spending and about 40% of extension spending. Given a matching rate of about 50%,[9] this implies that only about one-third to one-half of all research dollars and about 20% of extension dollars are freely allocated by states over and above the required matching share.[10] Since the grants are closed-ended and since most states spend more than their matching share, a marginal increase in federal dollars would have an income effect but no price effect if governments responded as if they were rational individual consumers. There is little reason to suppose, however, that models of individual behavior can be applied uncritically to studies of government actions. In fact, evidence from other public programs does not support such analogies. Most of these studies show that governments respond as if lump sum grants reduced the per unit price of the public service.[11] This so-called "flypaper" effect (i.e., "money sticks where it hits") has been explained in terms of a money illusion deliberately perpetuated by budget maximizing politicians.[12] Suppose that the cost of one unit of public service is $1 and that the federal government gives the state government a lump sum grant of R. If total state spending on this service is B, then proponents of this theory hypothesize that voters believe that the tax cost of an extra unit is $\frac{B-R}{B}$ which is less than the actual cost of $1. The larger is R, the smaller is this perceived tax cost, and the more of the service people want. Unless the income elasticity of demand for the service is very high, a grant to the government will generate more spending on the service than an equivalent grant given directly to the population.

5. Estimation Procedures

We estimate two alternative four equation systems utilizing the Zellner (1962) seemingly unrelated procedure. Actually our results are very close to OLS estimates since the only independent variables which differ in the equations are the federal funds variables (FEDRS/SB in the research equations and FEDEXT/SB in the extension equations.) We also imposed a restriction across the two research equations (STRS/SB and XSTRS/SB) and the two extension equations (STEXT/SB and XSTEXT/SB) which forced the federal funds coefficients to be consistent in both equations.[13]

We report two versions of the statistical model to illustrate two alternative approaches to measuring a reapportionment effect (Table 1). The first version relies on the PCNTC (percent necessary to control) variable to measure a reapportionment effect. The second version interacts the post-apportionment dummy variable (APP) with farm income (NFY/TPY), farm population (FPOP/TPOP) and federal grants (FEDRS/SB, FEDEXT/SB) to estimate shifts in the effects of these variables which can be arguably attributed to reapportionment. Since RESFMRS is only available for recent years, we also estimated equations using the post-apportionment period taken by itself (Table 2).

III. Results

Our results (Tables 1 and 2) help to distinguish between the influence of the federal structure of government, the political organization of farmers, and basic measures of their numbers and income. Clearly, much of the interstate variation in states' spending can be explained with no help from measures of government structure or federal grants. A high farm income share (NFY/TPY) is linked to high budget shares for research while the farm population share (FPOP/TPOP) is a significant determinant of extension spending. In contrast, income is a much less important determinant of extension spending, and population has no significant impact on research spending.[14] These results are consistent with the idea that agricultural research is of more direct benefit to farmers in proportion to their income while extension benefits are proportional to the size of the farm population. Therefore, they suggest that interstate differences in spending are tied to interstate differences in benefits.

However, the results also imply that it is not enough simply to know how important farming is in a state. The regressions indicate that political structure affects state choices. First, consider legislative apportionment. The results in equations (2), (4), (6), (8) in Table 1 support our predictions about the impact of reapportionment especially for research. Although farm population fell over this period as a share of the total population, on the margin its impact increased. For extension, the main impact is on "excess" state spending where the coefficient on the farm income share falls to 20%

of its preapportionment value and the coefficient on the farm population share more than doubles. (There was, of course, also a large shift in the elasticities. See Table 3.)

Another way of looking at the impact of state legislative apportionment is through PCNTC which measures the percent of the population needed to elect 50% of the legislature. In 1964 the mean of PCNTC was .32 with a range of .12 to .48. By 1969, after reapportionment, the mean was .48 with a range of .45 to .52. This variable helps explain interstate differences in research appropriations although the significance level is not very high. The higher the level of rural overrepresentation in state legislatures (the lower is PCNTC), the higher the budget share. Apparently, reapportionment has reduced farmers' power to affect the level of research spending.

Second, we examine two variables which measure the ability of farmers to organize to pursue their interests. One, membership in marketing cooperatives (MCOOP), is insignificant. This casts doubt on anecdotal testimony which emphasizes the power of the cooperative movement as well as on the results of Guttman (1978) and Huffman and Miranowski (1981). In contrast, we have employed a new variable which does have a high level of explanatory power for both research and extension. For recent years, we know whether farmers were particularly successful in electing other farmers to the legislature (RESFMRS). An increase in this variable implies added support for farm programs (Table 2).[15]

Third, the results for the full data set suggest that states do try to free ride off the research of others especially for livestock research (SPLVSTK). This effect applies to extension spending as well.[16] Apparently, the possibility of borrowing others' livestock research does not require states to spend much to adapt this research to local conditions. Even without direct evidence on productivity, this free riding suggests that the overall level of spending will be inefficiently low.

Finally, federal grants appear to have an important "price" effect on state appropriations. Almost all states spend more than their required matching share. Therefore, on the margin the state government should treat the grant like a lump sum grant. Analytically the subsidy is no different from an untied cash grant from the Federal government. Since agricultural research and extension spending each average about one quarter of one percent of a state's budget, it seems plausible to assume that a $1 increase in a state's income would produce only a very small increase in total spending on these programs even if the income elasticity of demand for the programs were large. Thus if the marginal increase in grants were treated in this way, <u>state</u> appropriations on agricultural research and extension (STRS, STEXT) would fall by almost one dollar. If the coefficient on federal grants in the state appropriations equation were almost minus one dollar, "excess" spending would fall by two dollars (one dollar to match the federal grant and one dollar to be spent elsewhere). The results do not support this view of the marginal effect of grants. Although on the margin they are "really" untied lump sum grants, governments appear to treat these funds as if they lowered the marginal cost of agricultural research and extension. It is not clear why this happens, but it is consistent with other research showing that Federal money "sticks where it hits." In fact, the result is stronger than this. Not only does the Federal money stay in agricultural research and extension but it also seems to stimulate state spending. The closed-ended matching grants appear to have price effects even when the matching share is exceeded. Instead of being close to minus one, the coefficients on federal funds are positive. They are .15 for research and .75 for extension (thus excess research spending falls by 85 cents and excess extension spending falls by 25 cents).[17] In recent years the price effects are even stronger especially for research. (See row (7) in Table 1 which reports the coefficient on (APP)*(FEDRS/SB)).[18]

Table 3 summarizes our estimates in the form of elasticities computed at data means. These elasticities not only summarize our estimates but also suggest implications for the future growth in spending. The effects of the variables PCNTC (reapportionment), SPLVSTK (spill-in), and CSHARE (crop share in output) are unlikely to change very much in the next decade or so. Reapportionment, of course, had the additional effect of shifting the basic support base for both research and extension away from farm income and toward farm population. However, even if farm population were to grow at the same rate as farm income in the future, both state research and state extension spending would fall as a proportion of state budgets. The sum of the post-apportionment elasticities is consistently less than one.

Table 1. Regression Estimates: Full Data Set.

Independent Variables	Dependent Variables STRS/SB		XSTRS/SB		STEXT/SB		XSTEXT/SB	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Intercept	.236	.172	.311	.240	.168	.160	.216	.172
	(3.90)	(2.70)	(5.12)	(3.76)	(3.18)	(2.88)	(4.10)	(3.12)
(1)TPY	-.0020	-.0013	-.0028	-.0022	-.0011	-.0010	-.0019	-.0002
	(3.65)	(2.47)	(5.29)	(4.07)	(2.46)	(2.17)	(4.32)	(3.89)
(2)NFY/TPY	1.465	1.976	1.784	2.126	-.017	.719	.514	.968
	(6.61)	(5.06)	(8.04)	(5.43)	(.09)	(2.08)	(2.61)	(2.82)
(3) (2)* APP	-	-.996	-	-.815	-	-1.01	-	-.848
		(2.18)		(1.78)		(2.51)		(2.12)
(4) FPOP/TPOP	.151	-.150	.132	-.124	.468	.198	.629	.361
	(.89)	(.66)	(.79)	(.54)	(3.01)	(.94)	(4.06)	(1.72)
(5) (4)*APP	-	.518	-	.519	-	.274	-	.565
		(1.61)		(1.61)		(.90)		(1.86)
(6)FEDRS/SB[1] FEDEXT/SB	.154	.154	-.846	-.846	.752	.737	-.248	-.263
	(1.58)	(1.26)	(8.70)	(6.87)	(14.09)	(11.73)	(4.65)	(4.19)
(7) (6)*APP	-	.323	-	.323	-	.108	-	.108
		(2.15)		(2.15)		(1.17)		(1.17)
(8) PCNTC	-.179	-.146	-.223	-.186	-.083	-.075	-.80	-.037
	(1.56)	(1.25)	(1.95)	(1.58)	(.79)	(.71)	(.77)	(.35)
(9) MCOOP	.011	.013	.0010	.0019	-.003	-.0013	-.003	-.006
	(1.19)	(1.39)	(.11)	(.20)	(.39)	(.16)	(.39)	(.74)
(10) SPCROP	-.0005	-.0005	-.0006	-.0005	-.0005	-.0005	-.0003	-.0002
	(1.23)	(1.07)	(1.37)	(1.21)	(1.15)	(1.20)	(.39)	(.62)
(11) SPLVSTK	-.0011	-.0010	-.0013	-.0012	-.0007	-.0006	-.0008	-.0008
	(3.38)	(3.01)	(4.02)	(3.68)	(2.30)	(2.20)	(2.69)	(2.78)
(12) CSHARE	.084	.101	.039	.062	.005	-.002	-.048	-.037
	(2.15)	(2.57)	(1.00)	(1.57)	(.13)	(.05)	(1.41)	(1.06)
(13) SOUTH	-.004	-.006	-.008	-.011	-.035	-.038	.020	.014
	(.25)	(.40)	(.52)	(.74)	(2.35)	(2.50)	(1.32)	(.90)

(14) D59	-.062	-.016	-.069	-.15	-.017	-.018	-.051	-.010
	(2.41)	(.48)	(2.72)	(.43)	(.74)	(.62)	(2.20)	(.34)
(15) D64	-.026	.011	-.022	.024	-.004	-.008	-.018	.016
	(1.00)	(.33)	(.84)	(.74)	(.17)	(.28)	(.80)	(.55)
(16) D69	.022	.006	.056	.040	.012	.010	.017	.018
	(1.16)	(.31)	(2.87)	(1.98)	(.70)	(.60)	(.99)	(1.07)
(17) D74	-.021	-.028	.027	.021	-.094	-.099	-.002	.0003
	(.96)	(1.19)	(1.19)	(.89)	(4.56)	(4.53)	(.08)	(.02)
Weighted R^2 for System[2]	.7841	.7886	.7841	.7886	.7841	.7886	.7841.	.7882

t - statistics in parentheses

[1] FEDRS/SB in (1), (2), (3), (4); FEDEXT/SB in (5), (6), (7), (8).

[2] Equations (1), (3), (5), (7) run as a system, and equations (2), (4), (6), (8) run as a system.

Table 2 Regression Estimates: 1969, 1974, 1978

Independent Variables	STRS/SB	XSTRS/SB	STEXT/SB	XSTEXT/SB
Intercept	-.102	-.059	.021	.074
	(3.39)	(1.97)	(.78)	(2.75)
(1)TPY	-.000003	-.0007	.0001	-.0006
	(.01)	(1.52)	(.30)	(1.41)
(2) NFY/TPY	.778	1.122	-.322	.129
	(3.56)	(5.22)	(1.52)	(.63)
(3) FPOP/TPOP	.391	.444	.267	.710
	(1.84)	(2.12)	(1.24)	(3.37)
(4) FEDRS/SB	.792	-.208	1.044	.044
FEDEXT/SB[1]	(7.82)	(2.05)	(14.08)	(.60)
(5) RESFMRS	1.038	1.063	.728	.549
	(6.94)	(7.23)	(4.95)	(3.83)
(6) MCOOP	.012	-.002	.0063	-.0015
	(1.23)	(.17)	(.68)	(.17)
(7) SPCROP	-.00002	-.0001	-.00001	-.0001
	(.06)	(.24)	(.02)	(.25)
(8) SPLVSTK	.0002	.00003	.0002	-.00007
	(.69)	(.10)	(.76)	(.25)
(9) CSHARE	.317	.279	.044	-.015
	(6.81)	(6.09)	(.97)	(.35)
(10) SOUTH	.044	.047	-.025	.030
	(2.61)	(2.84)	(1.42)	(1.74)
(11) D69	.035	.070	.023	.025
	(2.06)	(4.19)	(1.48)	(1.63)
(12) D74	.044	.094	-.091	-.0039
	(2.02)	(4.42)	(4.23)	(.18)
Weighted R^2 for System	.5771	.5771	.5771	.5771

[1]FEDRS/SB in research regressions; FEDEXT/SB in extension regressions.

t - statistics in parentheses

Table 3
Elasticities of Estimates in Table 1
Computed at Data Means[1]

	STRS/SB		XSTRS/SB		STEXT/SB		XSTEXT/SB	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
TPY	-.09	-.06	-.21	-.17	-.05	-.04	-.15	-.16
NFY/TPY	.30		.61				.17	
PREAPP[2]		.41		.72		.14		.33
POSTAPP		.20		.41		-.09		.04
FPOP/TPOP					.26		.38	
PREAPP								.22
POSTAPP		.16		.25				.47
FEDRS/SB	.08		-.79					
PREAPP		.09		-.79				
POSTAPP		.26		-.44				
FEDEXT/SB					.59	.58	-.35	-.37
PCNTC	-.31	-.26[3]	-.65	-.54				
SPLVSTK	-.09	-.08	-.17	-.16	-.05	-.04	-.11	-.11
CSHARE	.12	.15		.15			-.12	

[1]Elasticities are only presented for variables whose parameters were significant at a 10% level or better.

[2]PREAPP = pre-apportionment; POSTAPP = post-apportionment.

The post-apportionment estimates use the means for the last three data sets.

[3] t = 1.25, slightly below 10% significance level.
Table A2. Logarithmic Form Regressions - Full Data Set

IV. Implications for the Future

The absolute level of real spending, state plus federal, for agricultural research and extension has been roughly constant for the past ten to fifteen years and spending relative to the value of agricultural product has declined by roughly 30 percent over this period.[19] Our results suggest that part of this relative decline is due to the fall in the share of farm income and farm population in state totals. Since this downward trend is likely to continue, R and D spending cannot be expected to grow in real terms. Reapportionment may have caused a one time decline in states with high farm income shares. The countervailing increase in the importance of farm population in state spending decisions gives little grounds for optimism, however, since the farm population continues to fall as a share of the total. Thus unless federal funding for agricultural research and extension or total state budgets increase rapidly, the proportion of agricultural product invested in public sector research and extension will continue the decline which began about fifteen years ago. Neither possibility appears likely in the present political climate. Private sector research and extension has, however, increased over the period of our study. Since there are no adequate measures of these investments, however, we have been unable to incorporate them into our analysis. It is not obvious, however, that private agricultural suppliers will adequately make up for the relative decline in public spending. If the productivity measures are accurate,[20] agricultural research and extension appears to be one area of government spending where a study of the marginal benefits would show that an increase rather than a decrease in public support was warranted.

Appendix I

Variable Definitions

The dependent variables are defined as follows:

STRS/SB: State appropriations for agricultural research in thousands of dollars (STRS) divided by total state and local government spending from own sources in hundreds of thousands of dollars (SB). Thus STRS/SB is one hundred times the budget share. We have included local revenues in SB to correct for arbitrary differences across states in the division of functions between levels of government. In fact, the form of the revenue variable is likely to be unimportant. The alternatives we considered were all highly correlated. State revenues from own sources in 1974, for example, has a correlation coefficient of .991 with SB. The source for SB is U.S. Bureau of the Census, Governmental Finances. Sources for STRS are USDA Funds for Research and USDA, Cooperative State Research Service, Inventory of Agricultural Research. These sources are not completely compatible. Funds for Research was discontinued in 1975 and the CSRS data is available beginning with the 1970 data set. In the results in the text, Funds for Research was used through 1974. Using CSRS data for 1970 and 1974 made only a minor difference in the results.

XSTRS/SB: STRS minus an estimate of matching funds divided by SB. Discussion with officials at the USDA and study of the laws indicates that XSTRS can be approximated as:

$$XSTRS/SB = (STRS - (\text{Federal grants for research in thousands of dollars} - 90))/SB.$$

In other words, each state receives $90,000 and must match other grants dollar for dollar. See USDA Cooperative State Experiment Station Services (1962, pp. 219ff), and the laws cited in footnote 9.

STEXT/SB: State appropriations for agricultural extension in thousands of dollars divided by SB. The numerator (STEXT) is calculated by subtracting federal grants from total state spending on extension. The source for total state spending is unpublished data from the USDA, Federal Extension Service.

XSTEXT/SB: STEXT minus an estimate of matching funds divided by SB. USDA officials estimate that the share of grants requiring matching was 55% in 1978, 56% in 1974, and 74% in earlier years. (Conversation with Daniel Domingo, USDA Extension Service).

Therefore, XSTEXT/SB = (STEXT - A*federal grants for research in thousands of $)/SB,

where A = .55 in 1977
A = .56 in 1974
A = .74 in 1958, 1964, and 1969.

The independent variables are defined as follows:

NFY/TPY: Net Farm Income/Total Personal Income. (Source: U.S. Dept. of Commerce, Statistical Abstract of the U.S.)

FPOP/TPOP: Farm Population/Total Population. Sources: U.S. Department of Agriculture, Farm Population Estimates, 1910-1970, U.S.D.A. ESCS-86, August, 1980, and U.S. Dept. of Commerce, Bureau of the Census, Population Census. Farm population is defined as "all persons living in rural territory on places of 10 or more acres, if as much as $50 worth of agricultural products were sold from the place in the reporting year. It also includes those living on places of under 10 acres, if as much as $250 worth of agricultural products were sold from the place in the reporting year." (P.6, U.S.D.A., ESCS-86). A new definition based on sales is being considered by the U.S.D.A., but is not reflected in the numbers used here. For 1974, the data for 1969 were used since state by state estimates are not available after 1970. For 1979 the U.S. Department of Agriculture estimated the farm population in nine regions of the U.S. Thus farm population for the last data set was estimated by first calculating the share of each state in the farm population of its regional division in 1970. This share was then multiplied by estimated farm population in the region in 1979 from U.S.D.A. publication ESCS-86, August, 1980. This procedure assumes that each state in a region lost farm population at the same rate as the region as a whole.

CSHARE: The dollar value of crop output divided by the dollar value of all farm output (Source U.S.D.A., Census of Agriculture).

TPY: Total Personal Income, in billions of constant dollars. The data are deflated by the GNP Deflator (1959=100). TPY is highly correlated with SB. Regressing SB in 1974 on TPY and total population (TPOP) in thousands ($x10^3$) yields:

$$SB = -1431 + 195TPY - .24TPOP$$
$$(.63) \quad (4.98) \quad (.12)$$
$$R^2 = .96$$

SPCROP and SPLVSTK: Spill-in Research Stock. Cumulated research expenditures in billions of dollars (using information from Evenson 1978) on crop and livestock research, respectively, in similar geoclimatic regions in other states. Sixteen regions were defined from data published in the 1957 U.S.D.A. Yearbook of Agriculture. Each region was further divided into sub-regions. Studies by Evenson & Welch (1975) and Evenson (1978) concluded that crop research borrowing is primarily confined to similar subregions while livestock research borrowing is broader in scope and takes place across regions.

FEDRS/SB: Federal Spending for agricultural research in thousands of dollars divided by SB. Measured as 100 times the budget share. (Source: U.S.D.A. CSRS, Inventory of Agricultural Research and unpublished data from the U.S. Department of Agriculture).

FEDEXT/SB: Federal spending on extension divided by SB. Measured as 100 times the budget share. (Source: unpublished data from the U.S. Department of Agriculture, Federal Extension Service).

MCOOP: The number of farmers who are members of marketing cooperatives divided by the total number of commercial farms (i.e., farms selling products valued at over $2500 per year). The cooperative variable is often greater than one (mean 1.4) because many farmers are members of several marketing cooperatives. Service coops are omitted because they frequently include a heterogeneous collection of farmers with few common political interests. (Source: U.S. Department of Agriculture, Farmer Cooperative Service, Statistics of Farmer Cooperatives, and U.S. Department of Commerce, Statistical Abstract of the U.S.).

PCFRMR: The percentage of state legislators who list farming as their occupation. The mean of PCFRMR is .115. (Source: Insurance Information Institute (1976)). The data are only available for 1976 and 1978. For 1969 and 1974 we used the 1976 data since this variable appears to be relatively stable from year to year for individual states.

PCNTC: The share of the population needed to control the state legislature (PCNTC). Because this variable is available separately for each house of the state legislature, we averaged together the two shares.

Since a law must pass both houses and since the houses often differ widely in the number of members, this seemed to be a better procedure than using the percent needed to elect 50% of the total number of members. Source: Book of the States.

A second apportionment measure (SMCTY) is available for the early years. For 1950 and 1960 Paul David and Ralph Eisenberg calculated the share of each state's legislature representing counties with less than 25,000 people. If the people in these counties are heavily dependent upon agriculture for income and employment, this number is an alternative indication of "excess" agricultural political strength. (Source: David and Eisenberg, 1961). One would also expect this measure of farmers political strength to be associated with NFTPY and FRTPOP. A regression for the years 1954, and 1958 and 1964 indicates that this is so. (For 1964 and 1958 the 1960 values for SMCTY were used and for 1954 we used the 1950 data). The result was

$$\text{SMCTY} = \underset{(4.78)}{121.37} + \underset{(3.78)}{1877.4} + \underset{(2.46)}{763.57}\ \text{FRTPOP}$$

$$R^2 = .50$$

Using the residuals of this regression in regressions involving only the preapportionment years showed that this variable had little explanatory power.

Post-apportionment variables: APP = 1 if the data point is in the post-apportionment period (1969, 1974, 1978) and = 0 otherwise. This variable is multiplied by several other independent variables as a means of measuring reapportionment effects.

A dummy variable (SOUTH) that equals one if the state is a Southern State. We use the U.S. Government's definition of the south. Thus SOUTH equals one for the states: Delaware, Maryland, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida, Kentucky, Tennessee, Alabama, Mississippi, Arkansas, Louisiana, Oklahoma and Texas.

Dummy variables for each of the data sets except 1978.

Table A-1

Means and Standard Deviations

	Units	All Data Sets		1969, 1974, 1978	
		Means	Std.Dev.	Means	Std.Dev.
STRS/SB	share x 100	.239	.145	.232	.146
XSTRS/SB	share x 100	.144	.119	.150	.115
STEXT/SB	share x 100	.259	.148	.229	.130
XSTEXT/SB	share x 100	.144	.096	.143	.089
NFY/TPY	share	.049	.052	.047	.056
FPOP/TPOP	share	.087	.073	.073	.062
TPY	Billion $	11.16	13.59	13.31	15.28
SPCROP	-	20.28	14.78	23.38	15.80
SPLVSTK	-	18.93	19.03	20.94	21.22
MCOOP	Members/Farm	1.34	.768	1.32	.78
CSHARE	share	.347	.189	.338	.173
FEDRS/SB	share x 100	.135	.091	.127	.093
FEDEXT/SB	share x 100	.204	.146	.191	.141
PCNTC	share	.420	.090	.483	.017
RESFMRS*	share	-	-	0(-.12to.20)	.05

* Range given in parentheses

APPENDIX 2

Table A2 reports a logarithmic specification of the version one estimates reported in Table 1. The only substantive differences in these estimates are a) the federal funds effect is lower, in fact negative for research and b) the free-riding effect on livestock research is less significant. We believe that the fact that a number of variables are expressed in share form in the linear specification argues against placing emphasis on the logarithmic form. Logarithms of small shares are more sensitive to errors than the shares themselves. Accordingly we believe that the basic linear specification discussed in the text is more appropriate.

Table A2. Logarithmic Functional Forms

Independent Variables	Dependent Variables: LN(STRS/SB)	LN(XSTRS/SB)	LN(STEXT/SB	LN(XSTEXT/SB)
Intercept	-4.717	-6.089	-4.471	-5.401
(1) LN(TPY	-.345	-.691	-.161	-.488
	(5.02)	(5.90)	(4.09)	(6.95)
(2) LN(NFY/TPY)	.441	.725	.104	.150
	(8.35)	(6.71)	(2.50)	(1.55)
(3) LN(FPOP/TPOP)	-.033	.019	.269	.795
	(.45)	(.14)	(4.09)	(5.83)
(4) LN(FEDRS/SB)	-.245	-1.22	.137	-1.093
LN(FEDEXT/SB)[1]	(2.11)	(6.64)	(1.88)	(8.57)
(5) LN(PCNTC)	-.180	-.391	.034	.034
	(1.23)	(1.31)	(.29)	(.14)
(6) LN(MCOOP)	.049	.132	.002	.044
	(1.07)	(1.42)	(.06)	(.53)
(7) LN(CSHARE)	.091	.127	-.041	-.080
	(1.71)	(1.16)	(.97)	(.87)
(8) SPCROP[2]	.00005	.0013	-.0007	.0017
	(.03)	.32	(.42)	(.47)
(9) SPLVSTK[2]	-.0007	.0006	-.0016	-.0016
	(.52)	(.21)	(1.44)	(.60)

(10) South	.198	.218	.270	.681
	(2.64)	(1.45)	(4.34)	(4.91)
D59	-.232	-.490	-.068	-.556
	(2.40)	(2.52)	(.90)	(3.14)
D64	-.063	-.083	.050	-.062
	(.63)	(.41)	(.63)	(.34)
D69	.129	.448	.062	.173
	(1.31)	(2.36)	(.95)	(1.14)
D74	-.08	.270	-.230	.33
	(.74)	(1.21)	(2.51)	(1.66)
System R^2	.8047	.8047	.8047	.8047

t - statistics in parentheses.

[1] FEDRS/SB in research regressions; FEDEXT/SB in extension regressions.

[2] Not expressed in logs because of the existence of some zero values in SPLVSTK.

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FOOTNOTES

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1. Evenson, Waggoner and Ruttan (1979), Ruttan (1980), Ruttan (1982a). This research has been recently criticized by Pasour and Johnson (1982). Ruttan (1982b) convincingly responds to their criticisms. Although he himself believes that any of the older studies were methodologically flawed, he argues that more recent studies which also show high rates of return should be accepted.

2. See Rose-Ackerman (1980a) for a general discussion of the problematic links between efficiency and democracy, and Rose-Ackerman (1981) for an analysis of the link between federal structure and political choice. Rose-Ackerman (1980b) criticizes the widely held view that a federal system will facilitate innovation.

3. Consumer groups have been active in support of research on family economics, food technology, and related extension work at both the state and federal levels. They have stressed food additives etc. but have not been strong advocates of research designed to increase the productivity of farming. See Evenson (1982).

4. Nelson (1982) argues that this attempt to gain at the expense of competitors in other states distinguishes farming from home building and helps explain the greater support for research by farmers than building contractors.

5. Previous work indicates that a political-economic approach to explaining agricultural R and D spending is a useful one although these studies have also been unable to separate completely the benefits of research to farmers from their ability to influence politics. A study by Peterson (1966) showed that state support for agricultural research was related to state income and population variables in the same way that total state government spending is related to state income and population. Guttman (1978) argues that interest groups supply votes to politicians according to (1) the politician's support for the group's interest; (2) the size of the group; (3) individual demands within the group and (4) the level of organization of the group. A politician will demand votes from groups according to their marginal product in an electoral function. Guttman then finds empirical support for the interest group hypothesis by showing that per capita state support for agricultural research is related to the size distribution of farmers, co-op memberships, firms producing inputs, borrowable research and the proportion of owner operators. Most relevant to our research is a recent paper by Huffman and Miranowski (1981). They also try to explain per capita state spending on agricultural research as a function of the importance of farming in the state, the state's budget, and measures of the benefits of research to farmers and of their ability to organize

for political action. The most distinctive aspect of their study is an attempt to measure supply side variables. Their idea is a good one, but the interpretation of their results is complicated by simultaneous equation problems. Some of their measures of the productivity of research spending are, in fact, also related to the size of the research budget and so cannot be convincingly used to "explain" its level.

6. Book of the States. This number implies that districts containing 12% of the population could elect 50% of the legislators. In a majority rule system with two candidate races in each district, half the population could elect a majority of the legislature. Thus even with perfect apportionment just over 25% of the voting population of a state could elect a majority of a state senate or house.

7. Book of the States and National Municipal League (1970).

8. The regression results were:

$$PCFRMRS = 0.623 + 43.41\ NFT/TPY + 122.09\ FPOP/TPOP$$

$$(.95)\quad (3.16)\qquad\qquad (9.83)\quad R^2 = .79$$

9. See P.L. 89-106 (August 4, 1965); P.L. 88-74 (July 22, 1963); P.L. 87-788 (Oct. 10, 1962); P.L. 85-934 (Sept. 6, 1958); P.L. 352, chapter 790 (Aug. 11, 1955).

10. Every state spent more than the required matching share on extension according to our estimates. For research, a few small states did not exceed their matching share each year.

11. See Gramlich (1977, pp. 231-234) for a review of the literature.

12. The basic model was developed simultaneously by Courant, Gramlich and Rubinfeld (1979) and Oates (1979).

13. With a 50% matching rate, a one dollar increase in federal grants means that one dollar of state money must be used to satisfy the matching requirements. Thus if b_1 is the coefficient on FEDRS/SB when STRS/SB is the dependent variable, then in the XSTRS/SB equation the coefficient on FEDRS/SB must be $b_2 = b_1 - 1$. A similar condition holds for extension.

14. In the most recent data sets farm population is a significant determinant of excess research spending (Table 2). This result is consistent with the predicted effect of reapportionment discussed in the text.

15. A shift from the minimum residual (RESFMRS = -.12) to the maximum residual (RESFMRS = .20) shifts the predicted research share (times 10^2) by about .32. This is a large shift since the standard deviation of STRS/SB in this data set is .15 and of XSTRS/SB, .11.

16. This result does not carry over into recent years when we have a measure of RESFMRS.

17. The difference between research and extension may reflect the lower fungibility of extension spending. If federal funding is tied to particular programs at the margin it may effectively require some marginal matching by states.

18. See also Table 2 where the impact of federal grants is seen to be stronger for both research and extension for the years 1969, 1974, 1978. In fact, for extension, total appropriations increase by the entire one dollar required for matching. Since

the restriction, $b_2 = b_1 - 1$, must hold in every year (see note 13), the coefficients on the interaction terms APP * FEDRS/SB had to be equal to each other in both the STRS/SB and the XSTRS/SB equations. Thus if b_1 and b_2 are the grant coefficients in the early years, then the coefficients in the later year must have the form $b_1 + k$, $b_2 + k$, where k is a constant. Then $b_2 + k = b_1 + k - 1$ holds. The same restriction, of course, must be imposed for extension. Some of our results are sensitive to the functional form used in the regressions. Appendix 2 reports results for a log-linear specification and compares them to the results reported here. By and large the main conclusions are not altered, however.

19. Cooperative State Research Service U.S. Department of Agriculture, Inventory of Agricultural Research.

20. The returns may be somewhat lower in the 1970s than in the 1950s but they continue to be relatively high. See Bredahl and Peterson (1976).