IOWA STATE UNIVERSITY

Determinants of the Demand for State Agricultural Experiment Station Resources: A Demand-System Approach

Wallace Huffman, Robert Evenson

December 2003

Working Paper # 03028

Department of Economics Working Papers Series

Ames, Iowa 50011

Dec. 17, 2003

Determinants of the Demand for State Agricultural Experiment Station Resources: A Demand-System Approach

By

Wallace E. Huffman and
Robert Evenson*

Abstract: This paper presents new econometric evidence on state government's demand for resources to support local agricultural experiment station research. The econometric model consists of a complete-demand system covering four major resource sources, and it is fitted to annual observations on 48 contiguous states, 1970 to 1999. These results show that forces of total SAES budget size, national ranking of agricultural college and university programs, state demographics, and state's agricultural-output composition impact a state government's demand for resources for state agricultural experiment stations.

Corresponding author:
Prof. Wallace Huffman
Department of Economics
Iowa State University
Ames, IA 50011
515-294-6350
515-294-0221 FAX
whuffman@iastate.edu

* The authors are C.F. Curtiss Distinguished Professor of Agriculture and Professor of Economics, Iowa State University, and Professor of Economics, Economic Growth Center, Department of Economics, Yale University. We acknowledge useful comments obtained from a presentation at the National Meeting of State Agricultural Experiment Station Directors, Baltimore, MD, Sept. 24, 2002. We also acknowledge ESCOP Funding received from David MacKinzie and the University of Maryland and the Iowa Agriculture and Home Economics Experiment Station, project NC1003. Valuable research assistance was provided by Dong Yan.

Determinants of the Demand for Agricultural Experiment Station Resources: A Demand-System Approach

The state agricultural experiment stations (SAES) were established with federal funding by the Hatch Act in 1887. Initially all states received exactly the same amount, $15,000 per year. A new formula was established in 1955, which allocated 20 percent to each state equally, 26 percent according to a state's percentage of the U.S. farm population, and 26 percent according to a state's percentage of the U.S. rural population. In addition, 25 percent was allocated to cooperative regional research, now called multi-state research, and 3 percent for administration. The USDA first established a competitive grants research program in 1977 to address high-priority research areas. In 1985 it was amended to emphasize biotechnology, and in 1990 it was labeled the National Research Initiative (NRI) Competitive Grant Program (NRC 1995). Other, sometimes significant, USDA competitive research programs include the Fund for Rural America and The Initiative for Future Food Systems which were first initiated in 1996 and 2000, respectively. The latter programs, however, have not received stable funding.

The State Agricultural Experiment Station system was established with the opportunity to obtain funding from a variety of sources, including state government appropriations. Over the last half-century, major sources of funding have been state appropriations; federal formula funding; federal grants, contracts, and cooperative agreement; and private industry, commodity group, and NGO funding. The shares associated with each major source have been changing over time, and recently there has been much discussion and debate about possibly reducing federal formula funds and increasing competitive grants (Huffman and Just 1994, 1999, 2000; NRC 2000; Alston, Pardey, and Taylor 2001; Echeverra and Elliott 2001).

A surprisingly small amount of research has been undertaken to model funding of state agricultural experiment stations. A few exceptions do exist. First, Khanna, Huffman, and

Sandler (1994) presented econometric evidence for two different public-good formulations of a state legislature's demand for public agricultural research activity; pure public and joint-product models. Using state annual data for 48 contiguous states, 1951 to 1985, they found overwhelming support for a joint-products public goods model of state government demand for agricultural research. Although parameters differed across states, the income elasticity of demand was overwhelmingly in the 0.5 to 0.8 range and the price elasticity of demand was negative. Significant evidence of in-kind public research-spillin effects among states in regional groups occurred. This was the overwhelming evidence for the impure versus pure public goods model, i.e., a state must undertake research producing local public-good discoveries. To obtain these benefits, a state cannot borrow or free-ride on the research of other states. Second, Rubenstein, Heisey, Klotz-Ingram, and Frisvold (2002) evaluate different federal funding mechanisms for distributing funds to state-level institutions and scientists for agricultural research. They also use a regression model to test some hypotheses concerning the effects of various factors on the ability of states to receive funding through federal competitive-grants programs. They showed that the distribution of formula funds and federal competitive grants are similar by research-problem area (RPA) but special-grants distribution differs markedly. Competitive grants are, however, more basic research oriented. They found that a state university's strength or rankings of biological science programs and graduate program in agricultural sciences were important determinants of a state's federal grants share. The size of a state's agricultural sector and of the Ph.D.-agricultural scientist manpower also contributed positively to the federal grants share.

The objective of this paper is to present new econometric evidence on state government's demand for resources to support local agricultural experiment station research. The econometric model consists of a complete demand system covering major resource sources, and it is fitted to annual observations on 48 contiguous states, 1970 to 1999. These results show that forces of total SAES budget size, national ranking of agricultural college and university programs, state demographics, and state's agricultural-output composition impact a state government's demand for resources for state agricultural experiment stations.

A Brief Review of the Current Funding Situation

The amount and allocation of resources to the SAES system are reported in table 1 for 1980, 1990, and 2000. It shows that constant dollar amount of SAES system funding increased by 1.4 percent per year over the decade of the 1980s but a much slower 0.23 percent per year for the 1990s. This slow grow of the 1990s has been a major factor causing SAES directors to look about for potential new funding sources.

Over the past two decades, the distribution of SAES resources has shifted somewhat. The share of SAES funding from federal-formula funding has decreased from 17 percent in 1980, to 14 percent in 1990 to 12 percent in 2000 (USDA). Hence, the drop in the share of federal formula funds occurred during the 1980s rather than the 1990s. However, the composition of regular-federal funds has changed. The share of federal formula funds declined from 15.8 percent in 1980 to 10.3 percent in 1990 and to 9.0 percent in 2000. Competitive grant funding has increased from a negligible amount in 1980 to 2 percent in 2000. Hence, from regular-federal sources, federal formula funding remains large relative to competitive grant funding.

Other federal-government resources for SAES research has been growing rapidly. It composed 11.4 percent of the SAES system funding in 1980, 12.1 percent in 1990, and 16.2 percent in 2000 (table 1). The growth in this share has been primarily in non-USDA federal grants and contracts. State appropriations remain a dominant source of SAES funding, accounting for 55 percent of the total in 1980 and 1990 but declining to 50.1 percent in 2000. Other SAES funds from private industry, commodity group, and foundation funding have also been increasing as a share of the total. It was 9.2 percent of the total in 1980, 13.2 percent in 1990, and 15.3 percent in 2000. Hence, the relative importance of different major sources of funding for the states agricultural experiment stations has been changing over the past two decades. In contrast, the USDA's research agencies—ARS and ERS—show no significant change in funding sources. They are funded almost exclusively by federal government appropriations (see appendix table A1.)

A Model of Fund Shares

The motivation for the econometric model presented here is one of a state government's demand for resources from major sources to support local public agricultural research. Although a state legislature provides other public goods, we assume that the state legislature's utility function is additively separable, so we can focus only on the public agricultural research inputs and ignore the other good. Each state legislature is assumed to have a well-behaved neoclassical utility function where its utility depends on a pure public and pure private attributes, both of which are produced from an input of local public agricultural research (see Khanna, Huffman, and Sandler 1994). Local-state attributes or the environment of the state affects the translation of these inputs into utility. We envision state governments contribute to this collective activity and interactions among state legislature within regions (i.e., spillovers) are assumed to follow a Nash equilibrium (Khanna, Huffman, and Sandler 1994; Cornes and Sandler 1996).

State legislatures demand funds for SAES research from four major sources: (i) federal formula (ii) federal grants, contracts, and cooperative agreements, (iii) state government appropriations, and (iv) private industry, commodity groups, NGO'S, and sales. Let's assume that each source provides a unique input to the total state public agricultural research activity. Furthermore, lets assume that the preferences of the state legislature can be approximated by an almost-ideal-demand system (Deaton and Muelbauer 1980), which gives funding share equations:

$$(1)\ s_{it} = \alpha_i + \beta_i \ell n(F_t/P_t) + \gamma_i K_t + \mu_t,\ \ i = 1, 2, 3, 4,$$

where s_{it} is the i-th source-share in year t, F_t is the total SAES revenue or expenditures from all sources in year t, P_t is the research price index in year t, K_t is a vector of translating variable representing a state's absolute and relative scientific, agricultural, and political conditions. The variable μ_t is a zero mean random disturbance term. In each time period, the shares sum to unity i.e., $s_1 + s_2 + s_3 + s_4 = 1$. For estimation purposes, one of the four share equations can be deleted, and its coefficients can then be recovered from the other three equations. For example, let's drop the fourth share equation, then $\alpha_4 = -\alpha_1 - \alpha_2 - \alpha_3$, $\beta_4 = -\beta_1 - \beta_2 - \beta_3$, and $\gamma_4 = -\gamma_1 - \gamma_2 - \gamma_3$. Note that equation (1) also imposes the condition of homogeneous of degree zero in total expenditures (F_t) and the price index (P_t), i.e. revenue shares are a function of the size of total revenue/expenditures in constant rather than current dollars.

Given equation (1) the elasticity of demand for each of the four research activities can be summarized as follows:

$$(2)\ \eta_{iF} = 1 + \beta_i/s_i$$

$$(3)\ \eta_{iK} = \gamma_i/s_i K.$$

Equation (2) gives the income elasticity of demand for the i-th type of research activity, and equation (3) give the elasticity of demand for the i-th type of research activity with respect to a 1 percent change in K.

The Data and Empirical Results

The data is a panel of states, covering the 48 contiguous states, 1970 to 1999, or 1,440 observations. The dependent variables are the SAES-funding shares, and the regressors are the real budget constraint (i.e., total SAES expenditures/revenue) and translating variables. See table 2. These latter variables include: dummy variables for "Top-10," and "2rd-10" Gourman rankings of the local graduate program in agricultural sciences[1], dummy variables for National Research Council quality ratings of a state university's basic biological science faculty, lagged share of SAES funding invested in basic biological science research, public agricultural-research-capital spillin, private agricultural research capital, lagged U.S. share of farm population and of the rural population, lagged state share of farm and of rural population, and composition of farm sales in 1982—shares in field crops (excluding fruits and vegetables, horticulture and greenhouse products), fruits and vegetables, horticulture and green house, and livestock and livestock products. We also include regional indicator variables which represent regional-fixed effects which are time invariant. Although regional groupings of states are always somewhat arbitrary, we use the same groupings of states into regions as Khanna, Huffman, and Sandler (1994).

Because the summation across all funding shares adds up to unity, a disturbance to any one equation will be at least partially transmitted to other share equations. To take account of this contemporaneous correlation of disturbances in the three-fitted share equations to be fitted, we apply an estimation procedure that is equivalent to Zellner seemingly-unreality least-squares estimation (Greene 2002, p. 340-248). Our data set, which is a panel of states, 1970-1999, has 1,440 observations. The estimated coefficients and t-values for the federal grants and contracts; federal formula funds, and state government appropriations share equations are reported in table 3.[2] The results are surprisingly strong. The null hypothesis that each of the share equations individually has no explanatory power is clearly rejected. The test has 23 and 1,410 degrees of freedom and a critical value at the 1 percent level of about 2.77. The sample value of the F-statistic is 60.0 for the federal grant share equation, 236.1 for the federal formula funding equation, of value and 30.3 for the state appropriations equation. Furthermore, if one were to pool the results across all three-share equations into one joint test of no explanatory power, the null hypotheses would be soundly rejected at the 1 percent level. Hence, our model of state demand for these three types of public agricultural research activity has explanatory power.

Turning to the various regressors, the Gourman ranking of graduate agricultural science programs has a negative and significant effect on the federal-grant-funding share but a positive effect on state appropriations share. NRC ratings of a state university's basic-biological-science faculty (i.e., average of the rankings of biochemistry, microbiology and botany) are important. Being rated below the top category, which is "Strong-to-Distinguished," reduces the federal-grants share by 6 to 7.5 percentage points, with little difference in the size of the reduction occurring as a university moves down to "Marginal-to-Adequate" or "Insufficient-to-Marginal." However, being below the "Strong-to-Distinguished" category increases the SAES share from "other" funds by 4 to 12.5 percentage point with larger increases being for the lowest ranking. Federal formula funding, as expected, is largely unaffected by a university's NRC faculty quality ranking.

We find strong support for an impact of past SAES investments in basic-biological-science research SAES funding. A larger past investment by a state agricultural experiment station in basic biological sciences increases significant the current federal grant and contract share. This is offset largely by a reduction in federal formula and state appropriation shares. A larger public-agricultural-capital spillin reduces significantly a state's share of federal formula funding, which is largely off set by an increase the state appropriations share. The public agricultural research spillin capital has a generally weak effect on the federal grant and contract funding share. Hence, in these results, not much evidence exists of regional quotas in federal grant programs (US GAO 1994). The stock of private agricultural research capital has a surprisingly positive and significant effect on the federal grants and contracts share but a significantly negative effect on the federal-formula share. The impart on the other two shares are also negative but small.

Turning to demographics and compositions of agricultural sales, a state that have a larger share of the national farm population obtains a significantly larger share of federal formula funds as expected, given the nature of the formula, but it also increases the share from state-government appropriations and federal grants and contracts. The positive impacts are offset by a large negative effect of U.S. farm population on the funding share from “other” sources. A state’s rural population share has a positive and significant effect on the federal formula and “other” shares which are offset by negative impacts on state appropriations and the federal grant shares.

An increase in a state’s farm sales in fruits and vegetables relative to field crops increases significantly the federal-grant and contract share and is offset by a negative impact on the state-appropriations share. A larger share in horticulture and greenhouse sales relative to field-crop sales increases significantly the competitive grant and contract share and is offset by reduction in state appropriation and “other” fund shares. A larger livestock-sales share significantly increases the federal grant and contract share and reduces the significantly state-appropriations share. Hence, state governments tend to fund field crop research, fruit and vegetable, horticulture and greenhouse, but livestock research seems to be attractive to federal grant and contract funding. In particular, livestock researchers may have access to a larger pool of federal grant and contract funds from perhaps the NIH, whereas field crop research does not have any such large national pool of research funds to tap.

Our results show statistically significant regional effects, which are measured relative to the Central Region. They suggest, other things equal, that the North Central Region has an advantage in federal grants and contracts relative to all other regions. In particular, the Northeast, Southeast, Northern Plains, and Southern Plains, are at a significant disadvantage relative to the Central Region. The Pacific Region seems to be favored by formula funds compared to the Central Region (and other regions). The Southern Plains, Southeast, Northeast, and Mountain Region are favored by state appropriations relative to all other regions.

We believe that the results in table 3 are new, exciting and provide much food for thought by the directors of the state agricultural experiment stations and state legislators. To gain added insight into the responsiveness of the demand for different types of public agricultural research, we have converted selective coefficients in table 3 into response elasticities, evaluate at the sample mean of the date set, and reported them in table 4. We highlight only a few of these results. The revenue/expenditure elasticity of demand for federal- grant-research activity is 1.58, federal-formula-funded activity is 0.4, state-government-funded activity is 0.96, and of privately-funded activity is 1.35. Hence, as the experiment-station budget grows in real terms, federal grants and contracts, and the private sector grants and contracts can be expected to rise relatively, formula funded share to decline, and the state government's share to stay approximately the same. If a state land grant university can move up to the top quality NRC ranking of its basic biological science faculty, e.g., from "Good-to-Strong" to "Strong-to-Distinguished" this will increase the demand for federal grants and contracts and for state government appropriations but at the expense largely of a reduction in demand for "other" funds, e.g., private sector grants and contracts. If state agriculture experiment stations increase their current share of research funding in the basic biological sciences, they can expect an increase in demand in the future for federal grants and contracts. This, however, would be expected to require a large investment in scientific expertise and hence comes at a significant resource cost. States that experience a decrease in their share of the U.S. farm population, due say to urbanization, will have a reduced demand for federal grants and contracts, federal formula funds, and state government appropriations but an increase the demand for “other” sources.

Conclusions

Although much discussion and debate have been associated with recent federal funding decisions for agricultural research, little modeling and econometric analysis of state government reactions to the changing funding climate has been undertaken. In this paper we presented a model of state government demand for resources going into public agricultural research at the state agricultural experiment stations. This model was converted into a set of equations to explain SAES funding shares. Our econometric evidence showed that a state university’s ranking of its graduate agricultural- science program and of it basic-biological-science faculty are important factors in determining SAE S funding shares. In this study, we found weak evidence of interstate externality affecting SAES funding.

As expected, our results showed that a state’s share of the national farm and rural populations is an important determinant of federal-formula funding for SAES research. However, a state’s own farm and rural population share also affected the demand for state-government and federal-formula funded research activity. The composition of a state’s agricultural output was shown to affect the demand for particular types of funding. Larger field crops production increase the demand for state-government-funded research, and larger livestock and horticultural and greenhouse production increase the demand for federal-competitive-grant funding.

The empirical evidence implies that some state's are in an unusually strong position to take advantage of significant increases in federal-grant funding for agricultural research but many others are extremely disadvantaged. Many of the factors which determine funding shares, e.g., research spillins, share of the national farm and rural population, university ranks--are largely outside the control of state legislations and SAES directors. Hence, the new results provide much food for thought in the on-going debate about alternative federal-funding programs for SAES research.

Although much research remains to be done on this topic, we believe that we have opened-up a new line of economic inquiry into the funding of public agricultural research in the United States.

References

Ahearn, M., J. Lee, and J. Bottom. "Regional Trends in Extension Resources," Paper presented at Southern Agricultural Economics Association Meeting, Orlando, FL, Feb 2002.

Alston, J.M., P.G. Pardey, and M.E. Taylor. "Changing Contexts for Agricultural Research and Development," in J.M. Alston, P.G. Pardey, and M.J. Taylor. Eds., *Agricultural Science Policy: Changing Global Agenda*. Baltimore MD: The Johns Hopkins University Press, 2001, p. 3-12.

Cornes, R. and T. Sandler. *The Theory of Externalities, Public Goods and Club Goods*. New York, NY: Cambridge University Press, 1996.

Deaton, A. and J. Muelbauer. "An Almost Ideal Demand System," *American Economic Review* 70(June 1980): 312-326.

Echeverra, R.G. and H. Elliott. "Competitive Funds for Agricultural Research: Are They Achieving What We Want?" in G.H. Peters and P. Pingali, Eds., *Tomorrow's Agriculture: Incentive, Institutions, Infrastructure and Innovations*, Burlington VT: Ashgate Publishing Co., 2001, pp. 442-468.

Gourman, J. *The Gourman Report: A Rating of Graduate and Professional Programs in American and International Universities*. Los Angeles, CA: National Education Standards, 1985.

Greene, W.H. *Econometric Analysis*. 5th Ed. Upper Saddle River, NJ: Prentice Hall, 2003.

Huffman, W.E. and R.E. Evenson. *Science for Agriculture: A Long Term Perspective,* Ames, IA: Iowa State University Press, 1993.

Huffman, W.E. and R. E. Evenson. "New Econometric Evidence on Agricultural Total Factor Productivity Determinants: Impact of Funding Sources." Iowa State University, Department of Economics Working Paper No. , Dec. 2003.

Huffman, W.E., A. Mc Cumm, and J. Xu. "Public Agricultural Reach with an Agricultural Productivity Emphasis. Data for 48 States, 1927-1995 "Iowa State University, Department of Economics, Staff Paper forthcoming.

Huffman, W.E. and R.E. Just. "An Empirical Analysis of Funding, Structure, and Management of Agricultural Research in the United States, "*American Journal of Agricultural Economics* 76(Nov. 1994): 744-759.

Huffman, W.E. and R.E. Just. "Agricultural Research: benefits and Beneficiaries of Alternative Funding Mechanism." *Review of Agricultural Economics* 21(Spring-Summer 1999): 2-18.

Huffman, W.E. and R.E. Just. "Setting Efficient Incentives for Agricultural Research: Lessons from Principal-Agent Theory." *American Journal of Agricultural Economics* 81(Nov. 2000): 828-841.

Johnson, D.K.N. and A. Brown. "Patents Granted in U.S. for Agricultural SOV, by State of Inventor, 1963-1999," Wellesley College, Wellesley, MA, June 2002.

Khanna, J.W., W.E. Huffman, and T. Sandler. "Agricultural Research Expenditures in the United States: A Public Goods Perspective, "*Review of Economics and Statistics* 76(1994): 267-277.

National Research Council. *Colleges of Agriculture at the Land Grant Universities: A Profile*. Committee on the Future of the Colleges of Agriculture in the Land Grant University System, Board on Agriculture. Washington, D.C.; National Academy Press, 1995.

National Research Council. *National Research Initiatives: A Vital Competitive Grants Program in Food, Fiber, and Natural Resources Research*, Washington, D.C.; National Academy Press, 2000.

Rubenstein, K.D., P.W. Heisey, C. Klotz–Ingram, and G.B. Frisvold. "Competitive Grants and the Funding of Agricultural Research in the U.S." *Review of Agricultural Economics* forthcoming.

Sandler, T. "Global and Regional Public Goods: A Prognosis for Collective Action," *Fiscal Studies* 19 (1998):221-247.

U.S. Bureau of the Census. *Census of Population 1970(1980:1990).* Washington, D.C.: U.S. Government Printing Office, 1970(1982, 1992).

U.S. Department of Agriculture. *Inventory of Agricultural Research: Fiscal Year 1970-1996.* Current Research Information System, Cooperative States Research Service, Washington, D.C. 1971- thru 1997.

U.S. General Accounting Office (US GAO). *Peer Review: Reforms Needed to Ensure Fairness In Federal Agency Grant Selection*. Report of the Chairman, Committee on Government Affairs, U.S. Senate. Washington, DC: U.S. GAO, June 1994.

Table 1. Amount and Distribution of Major Sources of Revenues of U.S. State Agricultural Experiment Stations, 1980-2000.

Sources	Current Dol., Millions			Constant 2000 Dol.[a], Millions			Distribution (%)		
	1980	1990	2000	1980	1990	2000	1980	1990	2000
Regular federal appropriations	136.9	223.6	292.6	322.1	305.0	292.6	17.0	14.0	13.1
Hatch, regional research, and other non-grant funds	127.2	163.9	200.9	298.8	223.6	200.9	[15.8]	[10.3]	[9.0]
CSRS/CSREES special grants	9.6	39.7	47.0	22.6	54.2	47.0	[1.2]	[2.5]	[2.1]
Competitive grants, including NRI	--	20.0	44.7	--	27.3	44.7	--	[1.2]	[2.0]
Other federal government research funds	91.8	193.3	360.4	216.0	263.7	360.4	11.4	12.1	16.2
Contracts, grants, and cooperative agreements with USDA agencies	24.4	49.5	75.0	57.4	67.5	75.0	[3.0]	[3.1]	[3.4]
Contracts, grants, and cooperative agreements with non-USDA federal agencies	67.4	143.9	285.4	158.6	196.3	285.4	[8.4]	[9.0]	[12.8]
State government appropriations	446.9	877.9	1,117.8	1,051.5	1,197.7	1,117.8	55.5	55.0	50.1
Industry, commodity groups, foundations	74.0	210.0	340.9	174.1	286.5	340.9	9.2	13.2	15.3
Other funds (product sales)	55.2	91.6	118.0	129.8	125.0	118.0	6.9	5.7	5.3
Grant total	804.8	1,596.5	2,229.7	1,893.6	2,178.0	2,229.7	100.0	100.0	100.0

Source: U.S. Dept. Agr. 1982, 1991, 2001.

[a] Obtained by deflating data in first three columns using the Huffman and Evenson (1993, p. 95-97 and updated to 2000) agricultural research price index with 2000 being 1.00.

[b] Amount received from industry and "other non-federal sources," excluding state appropriations and product sales or self-generated revenue.

Table 2. Variable Names and Definitions

Name	Symbol	Mean (St.D.)	Description
Budget share from federal grants and contracts	GR	0.115 (0.086)	The share of the SAES budget from National Research Initiative, other CSRS funds, USDA contracts, grants and cooperative agreements, and nonUSDA federal grants and contracts (USDA).
Budget share from federal formula funds	SFF1	0.183 (0.104)	The share of the SAES budget from Hatch, Regional Research, McIntire-Stennis, Evans-Allen, and Animal Health (USDA)
Budget share from state government appropriations	SFF2	0.524 (0.119)	The share of the SAES budget from state government appropriations (USDA)
Budget share from "other" funds	OR	0.178	The share of the SAES budget from private industry, commodity groups, NGO's and SAES sales (USDA)
Total SAES revenue 1984 dol.	REVP	9.624* (0.872)	The total SAES funds from all sources divided by the Huffman and Evenson (1993) research price index (1984=1.00)
Agricultural sciences rating			The Gourman (1985) rating of graduate programs in agricultural sciences—Dummy variable taking a value of:
	Top10	0.208 (0.406)	1 if an institution is rated in Top 10, and 0 otherwise
	2nd 10	0.188 (0.390)	1 if an institutions is rated 11-20, and 0 otherwise
	<20th	0.604	1 if an institution is rated below top 20, and 0 otherwise.
Quality of graduate basic biological science faculty			National Research Council (1982) rating of scholarly quality of doctorate program faculty averaged over biochemistry, microbiology, and botany. Dummy variable taking a value of:
Strong-to-Distinguished		0.062	1 if institution has average rating of 4 to 5; and 0 otherwise;
Good-to-Strong		0.167 (0.373)	1 if institution has an average rating of 3.0 to 3.99; and 0 otherwise
Adequate-to-Good		0.354 (0.478)	1 if institution has an average rating of 2.0 to 2.99; and 0 otherwise.

Marginal-to-Adequate	0.146 (0.353)	1 if institutions has an average rating of 1.0 to 1.99; and 0 otherwise
Insufficient-to-Marginal	0.271 (0.444)	1 if institution has an average value of 0 to 0.99; and 0 otherwise.
Share research investment in basic biological sciences$_{-2}$	0.219 (0.070)	Share of SAES budget allocated to the fields of science of biochemistry and biophysics, molecular biology, genetics, microbiology, biology genetics, microbiology, and physiology lagged 2 years (USDA)
U.S. farm population share	0.021 (0.015)	A state's share of the U.S. farm population in the last census of population (U.S. Dept. Comm)
U.S. rural population share	0.021 (0.015)	A state's share of the U.S. rural population in the last census of population (U.S. Dept. Comm)
State farm population share	0.037 (0.040)	The share of a state's population that is farm (U.S. Dept. Comm)
State rural population share	0.345 (0.152)	The share of a state's population that is rural (U.S. Dept Comm)
Farm Sales in 1982:		
Share field crops, excluding fruits, vegetables, horticulture and greenhouse crops	0.322	The share of a state's farm sales in 1982 that were in field crops, excluding fruits, vegetables, horticultural and greenhouse products (USDA)
Share fruits and vegetables	0.102 (0.122)	The share of a state's farm sales in 1982 that were fruits and vegetables (USDA)
Share horticulture and greenhouse	0.045 (0.074)	The share of a state's farm sales in 1982 that were horticulture and greenhouse products (USDA)
Share livestock	0.531 (0.171)	The share of a state's farm sales in 1982 that were livestock and livestock products
Public agricultural research spillin	18.018* (0.248)	The summation across all states in a region of the public agricultural research stock less a state's own contribution to the stock (see Khanna, Huffman and Sandler 1994). Each state's research stock derived in Huffman and Evenson 2003.

Private agricultural research capital private		6.076* (0.248)	A state's stock of private patents of agricultural technology. The number of patents (Johnson and Brown) for each year obtained by weighting the number of patents in field crops (excluding fruits and vegetables and horticultural and greenhouse products) and crop services; fruits and vegetables; horticulture and greenhouse products; and livestock and livestock services by a states 1982 sales share in field crops (excludes fruits, vegetables, horticultural and greenhouse products), fruits and vegetables, horticulture and greenhouse products and livestock and livestock products, respectively. Trapazoidal timing weights are applied to the 2 thru 18 year lagged patent totals and summed to obtain the private R&D stock (Huffman and Evenson 2003).
Regional indicators	Northeast	0.229	Dummy variable taking a 1 if state is CT, DE, ME, MD, MA, NH, NJ, NY, PA, RI, or VT; and 0 otherwise;
	Southeast	0.188	Dummy variable taking a 1 if state is AL, FL, GA, KY, NC, SC, TN, VA, or WV; and 0 otherwise
	Central	0.167	Dummy variables taking a 1 if state is IN, IL, IA, MI, MO, MN, OH, or WI; and 0 otherwise
	North Plains	0.083	Dummy variable taking a 1 if state is KS, NE, ND, or SD; and 0 otherwise;
	South Plains	0.104	Dummy variable taking a 1 if state is AR, LA, MS, OK, or TX
	Mountains	0.166	Dummy variable to buy a 1 if state is AZ, CO, ID, MT, NV, NM, UT, or WY; and 0 otherwise;
	Pacific	0.063	Dummy variable taking a 1 if state is CA, OR, or WA; and 0 otherwise.

*Values are in natural logarithms.

Table 3. Econometric Estimates of an Almost-Ideal-Demand System for State Agricultural Experiment State Funding by Source, 48 States: 1970-1999 (t-values in parentheses) [N = 1,440]

Regressors[a/]	Revenue Shares: Federal Grants & Contracts (1)	Federal Formula (2)	State Appropriations (3)	Other[b/] (4)
Intercept	-1.976 (11.80)	2.435 (18.84)	0.984 (3.69)	-1.443
Rn(Total SAES Revenue, 1984 dol.)	0.067 (16.08)	-0.109 (34.01)	-0.021 (3.24)	0.063
Ratings of Graduate Programs Ag Science (Gourman):				
Top 10 (=1)	-0.067 (4.95)	-0.002 (0.18)	0.179 (8.26)	-0.110
2nd 10 (=1)	-0.020 (2.90)	-0.022 (4.08)	0.095 (8.73)	-0.053
Quality Basic Biology Science Faculty (NRC):				
Good-to-Strong (=1)	-0.063 (6.21)	0.003 (0.37)	-0.030 (1.85)	0.090
Adequate-to-Good (=1)	-0.075 (6.93)	0.003 (0.35)	0.029 (1.70)	0.043
Marginal-to-Adequate (=1)	-0.064 (5.31)	0.021 (2.30)	-0.082 (4.26)	0.125
Insufficient-to-Marginal	-0.070 (5.60)	-0.007 (0.74)	0.000 (0.05)	0.077
Share SAES Research Inv. in Basic Biolog Science$_{-2}$	0.177 (5.89)	-0.136 (5.87)	-0.021 (3.24)	-0.020
Rn(Public Ag Res Spillin Capital)	-0.003 (0.56)	0.012 (3.69)	0.010 (1.46)	0.005
Rn(Private R&D Capital)	0.229 (9.77)	-0.165 (9.13)	-0.040 (1.07)	-0.024
U.S. Farm Population Share	0.710 (2.61)	0.137 (2.20)	0.494 (3.86)	-1.341
U.S. Rural Population Share	-1.165 (5.07)	0.075 (5.22)	-0.120 (4.08)	1.210

State Farm Population Share	-0.352 (4.36)	0.461 (2.20)	0.494 (3.86)	-0.603
State Rural Population Share	0.044 (2.38)	1.902 (10.73)	-0.123 (4.08)	1.823
Composition of Farm Sales (1982):				
Share fruits & vegetables	-0.277 (5.51)	-0.283 (7.30)	-0.010 (0.12)	0.016
Share horticulture & Greenhouse	0.774 (13.30)	0.028 (0.63)	-0.403 (4.36)	-0.399
Share livestock	0.253 (12.82)	0.020 (1.32)	-0.307 (9.78)	0.034
Regional Indicators:				
Northeast (=1)	-0.053 (4.54)	-0.018 (2.03)	0.036 (1.94)	-0.035
Southeast (=1)	-0.088 (7.94)	0.012 (1.34)	0.155 (8.74)	-0.079
Northern Plains (=1)	-0.045 (3.54)	-0.041 (4.18)	-0.005 (0.27)	0.091
Southern Plains (=1)	-0.086 (7.80)	-0.016 (1.88)	0.138 (7.85)	-0.036
Mountain (=1)	0.020 (1.67)	-0.044 (4.81)	0.037 (1.97)	-0.013
Pacific (=1)	-0.018 (1.53)	0.033 (3.60)	-0.023 (1.23)	0.008
R^2	0.493	0.793	0.330	

Table 4. Responsiveness of State Demand for Agricultural Research from Four Major Sources, 1970-1999[a/]

Variables (mean)	Sample Means	Federal Grants & Contracts (0.115)	Federal Formula (0.183)	State Appropriation (0.524)	Other (0.178)
			(percentage change)		
Total Revenue (+1%)	9.62[b/]	1.583	0.404	0.960	1.354
NRC Basic Science Faulty Rating moving from "Good-to-Strong" to "Distinguished-to-Strong"		0.548	-0.016	0.057	-0.506
Private Ag R&D Capital (+1%)	6.08	0.328	-0.148	-0.013	-0.022
Share SAES Research Inv In Basic Biolog Sciences (+0.01%)	0.219	1.195	-0.577	-0.031	0.030
Public Ag Research Capital Spillin (+1%)	18.02	-0.001	-0.004	0.001	0.002
U.S. Farm Population Share (+0.01%)	0.021	2.968	0.360	0.453	-3.622
U.S. Rural Population Share (+0.01%)	0.021	-4.824	0.195	-0.109	3.237
State Farm Population Share (+0.01)	0.037	-0.827	0.681	0.255	-0.916
State Rural Farm Population Share (+0.1)	0.345	0.111	3.013	-0.068	-2.969

[a/] Evaluated at the sample mean of the data, using estimated coefficients from Table 3.

[b/] Mean of ℓn(Total Revenue).

Table A1. Total Funds for Research, including Cooperative Agreements, by USDA Research Agencies, 1980-2000

Agency	Current Dollars, Millions			Constant 2000 Dollars[b] Millions		
	1980	1990	2000	1980	1990	2000
Agricultural Research Service	360.3	580.1	794.9	847.8	790.3	794.9
Regular Federal appropriations	360.3	570.9	775.7	847.8	777.8	775.7
Other funds	0	9.2	19.2	0	12.5	19.2
Economic Research Service	42.6	51.3	72.5[a]	100.2	69.9	74.8[a]
Regular Federal appropriations	42.4	51.3	71.6	99.8	69.9	73.9
Other funds	0.2	0	0.9	0.4	0	.9
Total ARS and ERS	402.9	631.4	867.4	948.0	860.2	869.7
Regular Federal appropriations	402.7	622.2	---	947.6	847.7	---
Other funds	0.2	9.2	---	0.4	12.5	---

[a]Data for ERS and for 1999. ERS did not report any data for CRIS for 2000.

[b]Obtained by deflating data in the first three columns using the Huffman and Evenson (1993, p. 95-97 and updated to 2000) agricultural research price index with 2000 being 1.0.

Endnotes

[1] We take the Gourman ratings at face value. If they do not contain any useful information, they will not have any explanatory power in our demand system. In contrast, if the rates have coefficients that are significantly different from zero, this will be an indication that they matter to the state legislators as the weigh the demand for SAES research funding.

[2] Given the federal formula, the allocation of federal formula funds among the sttes is relatively straight forward (see Introduction) but over time the size of the pool of funds may be affected by other factors.