Journal of Agricultural and Applied Economics, 37,1(April 2005):229–236

Higher Education Costs and the Production of Extension

David N. Laband and Bernard F. Lentz

Do cost considerations justify the current structure of production of extension services in which one or more providers exists in virtually all of the contiguous U.S. states? Provision of extension services has sizable cost implications for the host institutions. Yet, to our knowledge, there has been virtually no analysis of the impact of extension on higher education costs. Using academic year 1995–1996 data, we estimate a multiproduct cost function for 1,445 public institutions of higher education in the United States, including 65 that provide extension services. We find evidence of significant economies of scale with respect to the provision of extension services but no evidence of significant economies of scope between the provision of extension and the production of research, undergraduate education, or graduate education.

Key Words: costs, extension services, higher education, multiproduct cost function

JEL Classifications: I22, L89

Historically, cooperative extension services have been provided by public universities across the United States, with funding provided from both federal and state appropriations. However, given the slow, steady erosion of political power resulting from the fact that agriculture is a long-term declining industry in the United States, both in terms of share of Gross Domestic Product and share of employment, there has been increasing discussion in recent years of privatizing the production/distribution of extension services. In this regard, several researchers have examined empirically the demand for and value of extension (Birkhaeuser, Evenson, and Feder; Dinar 1989; Huffman), while others have considered aspects of privatization and funding (Dinar 1992; Huffman and Just; Ingram; Just and Huffman; LeGouis; Schuh; Scwartz and Zijp; White and Havlicek).

Given the importance of extension within the agricultural sector, the relative merits of public versus private funding of extension services surely command our collective scrutiny and debate. Surprisingly, perhaps, a related aspect of the discussion of the optimal provision of extension services has been altogether missing: whether cost considerations justify the current structure of production in which one or more providers exists in virtually all of the contiguous U.S. states. Provision of extension services has sizable cost implications for the host institutions. Yet, to our knowledge, there has been virtually no analysis of the impact of extension on higher education costs. Among a host of relevant questions, one might consider the following:

David N. Laband is Professor of Economics & Policy, Forest Policy Center, School of Forestry & Wildlife Sciences, Auburn University, Auburn, AL. Bernard F. Lentz is Director of Institutional Analysis and Research, University of Pennsylvania, Philadelphia, PA.
We are grateful to the USDA's Sharon Vessels for providing us with extension cost data for FY1996 and to two anonymous reviewers for helpful comments. Remaining errors are our responsibility.

D.N.L. was supported by a McIntire–Stennis grant administered through the School of Forestry & Wildlife Sciences at Auburn University.

- Are the costs of providing extension services fully recovered by universities from earmarked public appropriations?
- To what extent is provision of extension services characterized by (dis)economies of scale?
- Are there cost synergies between extension and other outputs produced by public universities, such as research and teaching?
- What are the implications of any observed (dis)economies of scale and scope for the cost efficiency of the current structure of producing extension services and for the extent to which privatization might result in natural monopoly?

In this paper, we seek to provide an empirical starting point for addressing these and related questions pertaining to the impact of extension on higher education, by estimating a multiproduct cost function for public universities with expenditures on extension added to the traditional product mix of undergraduate teaching, graduate teaching, and research. To our knowledge, however, there has been no previous investigation of the cost impact on institutions of higher education (IHEs) of providing extension services. Using academic year 1995–1996 data, we estimate a multiproduct cost function for 1,445 public IHEs in the United States, including 65 that provide extension services. We find evidence of significant economies of scale with respect to the provision of extension services, but no evidence of statistically significant economies of scope between the provision of extension and the provision of research, undergraduate education, or graduate education.

Overview of Research Methodology and Data

The general methodology for estimating how provision of certain types or levels of academic 'products' affects an institution's costs is fairly straightforward. Using detailed data on costs and 'outputs' (typically the number of full-time equivalent undergraduate or graduate students taught, number of degree programs or academic departments, amount of externally funded research, and the like) for a large number of academic institutions, the researcher uses multivariate regression to estimate the relationship between the level and type of output produced and the institution's costs. This permits the researcher to then estimate whether production of these outputs is characterized by general or specific economies of scale or economies of scope. Production is characterized by general (dis)economies of scale when total institutional costs (rise) fall when the production of all outputs is increased simultaneously. Production is characterized by specific (dis)-economies of scale when total institutional costs (rise) fall when the production of the specific output under consideration is increased, holding the production of all other outputs constant.

An economy of scope is, in effect, a cost savings triggered by producing one output in the presence of another. For example, it might well be the case that there is an economy of scope between production of graduate students and production of undergraduate students, when the former help provide low-cost instruction for the latter. Conversely, it has been argued that a university with highly paid faculty in professional (business, law, pharmacy, medical) schools has diseconomies of scope with the liberal arts and education programs because the faculty in these latter programs agitate for higher salaries than they'd likely receive in institutions without such professional programs.

Following in the tradition established by Baumol, Panzar, and Willig and developed specifically in the context of higher education by Cohn, Rhine, and Santos and Toutkoushian, we estimate a multiproduct cost function for IHEs. Our model is specified as a flexible fixed cost quadratic function, with a dummy variable F_i that assumes a value of 1 (0) for (non)positive amounts of the output Y_i:

$$C_i = a_0 + \sum_i a_i F_i + \sum_i b_i Y_i + \left(\frac{1}{2}\right) \sum_i \sum_j c_{ij} Y_i Y_j + \eta_i, \tag{1}$$

C_i refers to total expenditures by IHE i in

1996, a_0, and the a_i's, the b_i's, and the c_{ij}'s are scalars, and η_i is the error term, which is assumed to be independently and identically distributed. Output produced includes undergraduate education (measured as full-time equivalents, in thousands), graduate education (full-time equivalents, in thousands), research (measured as the number of scientific publications produced in 1996—see Toutkoushian et al.), and extension (the number of in-person extension contacts with constituents, aggregated across a number of different extension activities). The F_i variables reflect differences across IHEs with respect to the fixed costs of producing different product sets.

Economies of scale or scope are expressed, definitionally, in the context of changes in total cost. We can estimate what might be regarded as the 'fixed,' albeit indirect, cost of providing output i through the a coefficient on the dummy variable, F_i, in Equation (1), which assumes a value of one for schools producing output i and zero for schools not producing output i. The marginal cost associated with production of output i is estimated in the b and c coefficients; where the b coefficients estimate 'direct' cost effects and the c coefficients estimate cost effects that accrue by virtue of (dis)economies of scope between output i and other outputs. The overall marginal impact on total costs of production of an incremental unit of output i is found by taking the partial derivative of the estimated cost function with respect to output i, at the sample means of the variables.

Ray Economies of Scale

Let $C(Y)$ be the total cost of producing all of the n outputs (Y_i) and let $C_i = \partial C(Y)/\partial Y_i$ be the marginal cost of producing the ith output. Then the ray economies of scale coefficient, $S_n(Y)$, is defined by

$$(2) \qquad S_n(Y) = \frac{C(Y)}{\sum Y_i C_i(Y)}.$$

Ray (dis)economies of scale are said to exist if $S_n(Y)$ is (less) greater than one.

Product-Specific Economies of Scale

Let $C(Y_{n-i})$ represent the total cost of producing all of the n products except the ith one, and let $AIC(Y_i)$ denote the average incremental cost of the ith product, given by

$$(3) \qquad AIC(Y_i) = [C(Y) - C(Y_{n-i})]/Y_i.$$

Then the degree of product-specific (dis)economies of scale, $S_i(Y)$, is defined as

$$(4) \qquad S_i(Y) = AIC(Y_i)/C_i(Y).$$

(Dis)economies of scale are said to exist for the ith product when $S_i(Y)$ is (less) greater than one.

Economies of Scope

Economies of scope arise when production is characterized by complementarities among the outputs produced—i.e., it is cheaper to produce Y_i in conjunction with Y_j than to produce i and j separately. The degree of economies of scope, $SC_t(Y)$, for a product set t is calculated as

$$(5) \qquad SC_t(Y) = \frac{C(Y_t) + C(Y_{n-t}) - C(Y)}{C(Y)}$$

where $C(Y_t)$ is the cost of producing only the product set t, and $C(Y_{n-t})$ is the cost of producing all of the n products except those in the subset t. Economies of scope are said to exist if $SC_t(Y) > 0$.

Economies of scale and scope are calculated at the mean values of the variables in the model, as well as multiples of the mean values. The corresponding total cost functions can be graphed, displaying the regions of economies and diseconomies of scale.

Our data came from the National Center for Education Statistics 1995–1996 fiscal year surveys on IHE finances, enrollments, and compensation. From this large data set we identified a usable sample of 1,445 public institutions, of which 65 provided extension services. In most states, extension services were provided exclusively by the major land-grant university (the 1862 schools). However, in 16 states the production/distribution of extension services was shared among multiple IHEs, typically the major land-grant school and a smaller, historically black institution (the 1890 schools). Thus, the set of extension-producing schools tends to be dominated by the state land-grant schools, which are large, research-oriented institutions with undergraduate and graduate programs.

Extension needs and the programs that serve those needs vary from state to state. Consequently, it is not possible to specify a single, comprehensive metric that perfectly reflects all extension output for each state. Using a Freedom of Information request, we obtained reports provided to the U.S. Department of Agriculture (USDA) for 1996 by each state extension program director. From these reports, we identified a number of programs that involved personal contact between extension personnel and constituents. These reports contained information about the number of such contacts for certain programs in 1996. Our measure of extension 'output' provided in a specific state is the aggregate number of in-person contacts made by extension personnel under the following programs:

- Expanded Food and Nutrition Education Program (# families participating in diet/nutrition programs)
- Food Safety and Quality (# persons participating in food safety educational programs)
- Farm Safety (# persons participating in farm safety educational programs)
- Pest Applicator Training (# participants in pest training/educational programs)
- Sustainable Agriculture (# producers who adopted sustainable agricultural practices)
- Water Quality (# wells tested)
- Youth at Risk (# children served by extension-assisted day care; # children in literacy programs).

A problem with these data is that in states with more than one extension-producing university (i.e., with both an 1862 and an 1890 institution) the extension reports submitted to the USDA contain aggregated data for all extension-producing institutions therein. Rather than discard the data from the 16 states with multiple extension-producing institutions, we prorated the extension 'output' (the reported number of personal contacts) in these states by the proportion of each institution's total extension spending for 1996.

Our data on institution-specific publications for 1996 were obtained from the online data service (Web of Science) available through the Institute for Scientific Information at http://isi10.isiknowledge.com/portal.cgi?DestApp=WOS&Func=Frame.

Summary statistics for our data are reported in Table 1. Although, as indicated above, there are several states with 1890 institutions providing extension services, in most states extension is provided by a fairly large land-grant university. This is why the variable means are substantially larger for the set of extension-producing institutions than the set of all public institutions, which includes a large number of relatively small schools. The mean number of personal contacts for the set of programs identified above was 46,307 in 1996, with a high of 702,720. The next-highest state showed 290,499 contacts and several other states had over 100,000 contacts.

The specific model and estimation technique we used in our analysis can be found in Laband and Lentz; the only difference is that the current discussion is based on our having added extension as one of the products produced by public universities. Since we estimated a total cost function, we entered all outputs with linear, squared, and cubic terms—the standard economic depiction of the relationship between total costs and quantity of output produced. The estimation procedure was ordinary least-squares regression; our results are reported in Table 2. Because of the confirmed presence of heteroskedasticity (χ^2 = 39,149.9, $p < 0.01$) in the model, we report heteroskedasticity-adjusted chi-square tests of significance for the coefficient estimates in the far right column.

Table 1. Variable Descriptions and Sample Statistics

Variable Symbol	Description	IHEs That Provide Extension Services Mean	Std. Dev.	All Public Universities Mean	Std. Dev.
TC	Total IHE expenditures (millions of $)	351.019	279.477	65.652	131.414
AVECOMP	Average annual salary plus fringe benefits for nonmedical faculty	65,223.000	11,113.000	53,260.000	11,900.000
RESDUM	= 1 if publications > 0; = 0 otherwise	0.969	0.175	0.398	0.490
UGDUM	= 1 if undergraduate enrollment > 0; = 0 otherwise	1.000	0.000	0.995	0.069
GRADDUM	= 1 if graduate enrollment > 0; = 0 otherwise	1.000	0.000	0.354	0.478
EXTENDUM	= 1 if extension contacts > 0; = 0 otherwise	1.000	0.000	0.044	0.206
RES	# publications in 1996	1,284.344	1,379.791	161.693	631.741
UG	Full-time equivalent (FTE) undergraduate student enrollment	13,082.000	8,486.000	4,427.000	4,735.000
GRAD	Full-time equivalent graduate student enrollment	2,982.000	2,608.000	510.000	1,334.000
EXTEN	Extension contacts (in-person)	46,307.000	84,138.000	2,051.000	19,992.000
RESUG	FTE undergraduate enrollment × publications (millions)	25.841	35.698	2.432	12,719.000
RESGRAD	FTE graduate enrollment × publications (millions)	6.874	11.000	0.783	4,601
EXTENRES	Extension contacts × publications (millions)	86.630	192.088	3,837	43.906
GRADUG	FTE undergraduate enrollment × FTE graduate enrollment (millions)	58.693	75.007	6.984	27.847
COMPRES	Faculty compensation × publications (millions)	95,006.000	109,600.000	11,640.000	47,661.000
COMPUG	Faculty compensation × FTE undergraduate enrollment (millions)	920.509	686.201	263.213	335.869
COMPGRAD	Faculty compensation × FTE graduate enrollment (millions)	215.571	206.221	34.884	98.826
COMPEXTEN	Faculty compensation × extension contacts (billions)	3.094	5.385	0.137	1.292
EXTENUG	Extension contacts × FTE undergraduate enrollment (millions)	782.209	1,575.900	34.646	366.425
EXTENGRAD	Extension contacts × FTE graduate enrollment (millions)	184.603	418.783	8.176	95.368
Sample Size		65		1,445	

IHE is institute of higher education.

Table 2. Four-Output Cubic Cost Function Estimates for Public Universities

Variable	Coefficient Estimate	Standard Error	t-statistic	Heteroskedasticity-Adjusted χ^2
Intercept	−64.0861	12.1393	−5.28***	
RESDUM	2.5917	2.5185	1.03	0.88
GRADDUM	−0.5989	3.0062	−0.20	0.02
UGDUM	59.5394	10.3727	5.74***	1.74
EXTENDUM	30.1395	6.3634	4.74***	4.78***
AVECOMP	0.2314	0.1024	2.26**	2.37
RES	0.0985	0.0178	5.54***	1.07
RES^2	−3.6E-5	4.6E-6	−7.90***	3.91**
RES^3	2.2E-9	5.4E-10	3.99***	1.05
UG	0.0937	1.3944	0.07	0.00
UG^2	0.0918	0.1013	0.91	0.17
UG^3	−0.0012	0.0030	−0.40	0.02
GRAD	26.7473	8.7736	3.05***	0.95
$GRAD^2$	−5.2147	1.1161	−4.67***	3.94**
$GRAD^3$	−0.0204	0.0680	−0.30	0.01
EXTEN	0.0018	0.0007	2.66***	2.88*
$EXTEN^2$	−2.9E-9	2.0E-9	−1.47	0.18
$EXTEN^3$	1.5E-15	2.7E-15	0.54	0.02
RESUG	−0.0024	0.0005	−5.03***	0.94
RESGRAD	0.0223	0.0018	12.61***	5.00**
GRADUG	0.2066	0.2669	0.77	0.09
EXTENRES	1.8E-7	1.1E-7	1.66*	0.16
EXTENUG	1.9E-5	2.2E-5	0.90	0.21
EXTENGRAD	0.0002	0.0001	3.07****	1.14
COMPRES	0.0009	0.0003	3.36***	0.50
COMPUG	0.0891	0.0228	3.92***	5.73**
COMPGRAD	−0.0578	0.1339	−0.43	0.02
COMPEXTEN	−4.1E-5	1.2E-5	−3.77***	4.34**
Adjusted R^2	0.9629	Model F statistic		1,360.94***

Notes: *** Significant at the 1% level or better, two-tailed test; ** significant at the 5% level or better, two-tailed test; * significant at the 10% level or better, two-tailed test.

Findings

We estimated a 'fixed cost' of providing any extension services of just over $30 million in 1996. That is, holding other factors constant, public universities that produced extension services, regardless of level of service, had total costs that averaged nearly $30 million more than public universities that did not produce extension services. We then calculated the marginal impact of an additional personal contact, starting from the mean number of contacts (for the previously specified set of extension programs) at the extension-producing schools (46,307). At that level of extension activity, an additional contact increased total university costs by approximately $2,500. But while total costs increase with the number of clients served, the average cost of providing extension services declines continuously over the entire range of service exhibited by the institutions in our data (Figure 1). Likewise, there is only one institution producing extension services at a level characterized by increasing, rather than decreasing, marginal cost. For the most part, then, extension-producing universities are characterized by economies of scale. However, we find no evidence of either economies or diseconomies of scope between production of extension and production of un-

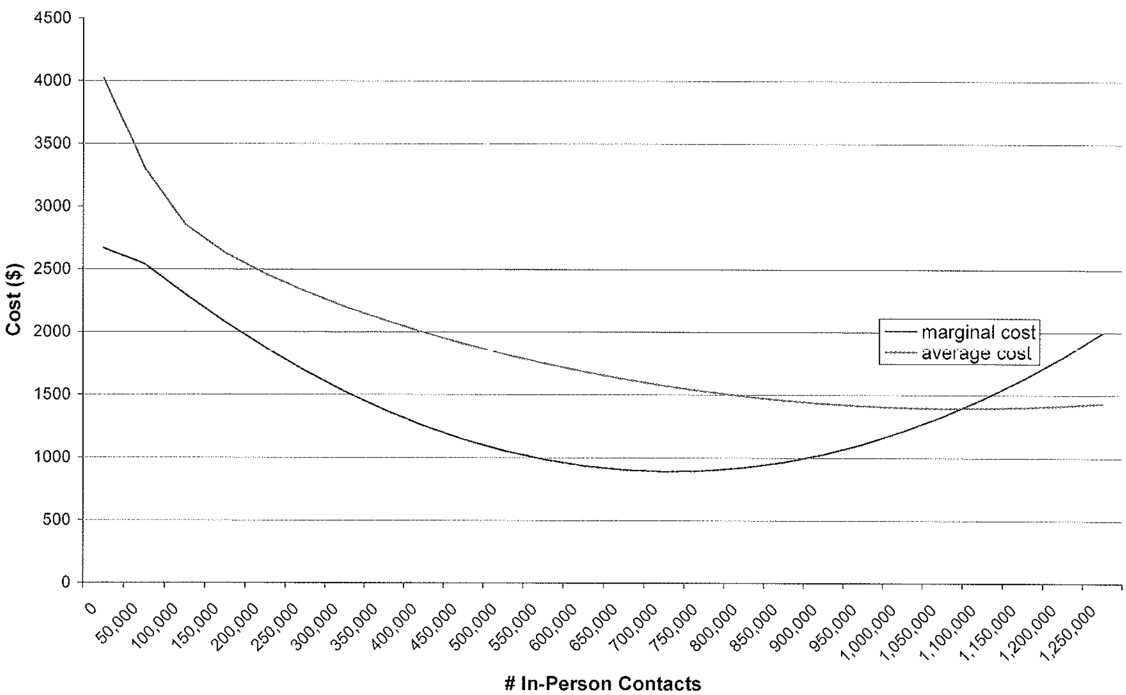

Figure 1. Marginal and Average Costs for In-Person Extension Contacts—1996

dergraduate education, graduate education, or research.

Discussion

One significant limitation to our analysis is the indistinct line between extension and research in our data. No doubt, some portion of the publications reported for extension-producing institutions is generated by faculty on extension appointments, pursuing extension-related activities. So there is an attribution problem in our data. Although this does not mean that our current estimation work is biased, it does mean that a more detailed specification of extension outputs in the model likely would provide additional insights about the cost impact of providing extension services. Specifically, a model with a greater number of extension outputs might reveal the presence of economies of scope between extension and research that our model does not reveal.

This said, we also note that extension output defined as in-person contacts plausibly is a substitute for extension research. That is, it seems likely that the more time is spent on personal contact with extension clients the less time is available to produce refereed publications. This would imply a diseconomy of scope between extension and research (given our proxies for each). We do not find evidence of such a diseconomy of scope, but additional investigation with detailed data on extension faculty appointments and outputs might help determine whether there is, in fact, such a trade-off.

Our findings suggest that there may be cost economies to be enjoyed by virtue of regionalizing the production of extension in some cases. For example, every single one of the New England states has an IHE that provides extension. Every single one provides extension services at a level that is characterized by strong economies of scale. Assuming that at least some of the extension outputs produced are substitutable across state lines, there would appear to be a strong case for regionalizing the production of extension in one or two New England universities, rather than the six that do so now. By the same token, our results suggest that privatization of extension might lead, in some cases, to natural monopoly, at a regional level, with the further implications for the pricing of extension services.

Our analysis has focused only on institutional costs, not the range and extent of benefits accruing from the production of extension. Nonetheless, our analysis of costs suggests that structural reorganization or redistribution of extension activity might be justified in terms of promoting cost economies.

[Received December 2003; Accepted August 2004.]

References

Baumol, W.J., J.C. Panzar, and R.D. Willig. *Contestable Markets and the Theory of Industry Structure.* New York: Harcourt Brace Jovanovich, 1982.

Birkhaeuser, D., R.E. Evenson, and G. Feder. "The Economic Impact of Agricultural Extension: A Review." *Economic Development and Cultural Change* 39(April 1991):607–50.

Cohn, E., S.L.W. Rhine, and M.C. Santos. "Institutions of Higher Education as Multi-product Firms: Economies of Scale and Scope." *Review of Economics and Statistics* 71(1989):284–90.

Dinar, A. "Provision and Request of Agricultural Extension Services." *American Journal of Agricultural Economics* 71(May 1989):294–302.

———. "Extension Commercialization: How Much to Charge for Extension Services." *American Journal of Agricultural Economics* 78(February 1992):1–12.

Huffman, W.E. "Assessing Returns to Agricultural Extension." *American Journal of Agricultural Economics* 60(December 1978):969–75.

———, and R.E. Just. "Funding, Structure, and Management of Public Agricultural Research in the United States." *American Journal of Agricultural Economics* 76(November 1994):744–59.

Ingram, P. "The United Kingdom Experience in the Privatization of Extension." *Public and Private Roles in Agricultural Development,* Proceedings of the Twelfth Agricultural Sector Symposium, J.R. Anderson and C. de Haan, eds., pp. 51–58. Washington, D.C.: World Bank, 1992.

Just, R.E., and W.E. Huffman. "Economic Principles and Incentives: Structure, Management, and Funding of Agricultural Research in the United States." *American Journal of Agricultural Economics* 74(December 1992):1101–08.

Laband, D.N., and B.F. Lentz. "New Estimates of Economies of Scale and Scope in Higher Education." *Southern Economic Journal* 70,1(July 2003):172–83.

LeGouis, M. "Alternative Financing of Agricultural Extension: Recent Trends and Implications for the Future." *Agricultural Extension: Worldwide Institutional Evolution and Forces for Change,* chap. 6, W.M. Rivera and D.J. Gustafson, eds. Amsterdam: Elsevier, 1991.

Schuh, G.E. "Privatization of Agricultural Research at Land Grant Universities." *Emerging Agricultural Technologies: Issues for the 1990's.* Washington, DC: U.S. Congress, Office of Technology Assessment, 1992.

Scwartz, L.A., and W. Zijp. "Public and Private Roles in Delivery of Extension Services." *Public and Private Sector Roles in the Provision of Agricultural Support Services.* Proceedings of the World Bank International Symposium, San Jose, Costa Rica, 17–19 May 1993. Washington D.C.: The World Bank, 1994.

Toutkoushian, R.K. "The Value of Cost Functions for Policymaking and Institutional Research," *Research in Higher Education* 40,1(1999):1–15.

———, S.R. Porter, C. Danielson, and P.R. Hollis. "Using Publication Counts to Measure an Institution's Research Productivity," *Research in Higher Education* 44,2(April 2003):121–48.

White, F.C., and J. Havlicek, Jr. "Optimal Expenditures for Agricultural Research and Extension Implications of Underfunding." *American Journal of Agricultural Economics* 64(February 1982):47–55.