Cost Relationships in Colleges of Agriculture

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Introduction

This paper is the beginning of what will hopefully be a broadening effort to discover and implement a set of decision support tools as well as business practices that will enable a clearer understanding of the cost relationships within higher education and specifically colleges of agriculture. While there are many aspects in analyzing costs, this paper looks at cost relationships as they relate to the instructional mission; (analyzing the relationships between a small number of inputs and outputs does this). Analyzing data elements such as student credit hours (SCH), full-year-equivalent (FYE) students, fixed and variable costs, yields output shown below.

The project was initially undertaken in an effort to understand and improve the decision support tools available to department and college level administrators. One goal is the integration of basic economic principals with key operational and institutional data in addition to modern electronic tools for decision support. Another major goal is to adopt business practices that integrate with institutional data, which generate easy to understand business models. These business models could be adapted to any number of key mission or academic activities of a given department or college. It is hoped that continuing this effort and others like will improve general understanding and help facilitate better management decisions.

Need for Improved Financial Information

The need for financial and cost information is not new. There has always been a need for good financial information centered on academic programs and related service activities. Over the last few years there has been intense pressure placed on the financial resources in higher education. This pressure comes from a number of areas, including the decreasing levels of public support, high labor costs relative to other costs and changing state priorities to name a few.

Current trends suggest that some areas of higher education adopt more of a revenue model, which emphasizes those activities that can generate revenue as a means to become more self-supporting. This action is in direct response to a fiscal climate of public fiscal conservatism relating to higher education as well to the other environmental issues facing higher education. While various revenue models continue to be explored, cost management and containment are becoming a bigger and bigger issue for many programs, departments and colleges. To manage and or contain costs we must first understand them. To do this we need to adopt tools and techniques that help us explain, report and model various activities.

Other trends include adoption of various revenue sharing models by some colleges and universities that generally focus on distributing instructional dollars based on level of teaching and instructional subsidy. This type of institutional strategy for promoting growth places heavy emphasis on cost controls, productivity, minimizing inputs and maximization outputs. In addition to revenue sharing some institutions have also adopted various cost sharing models as a means of spreading the impact of budget cuts, retrenchments and other fiscal adjustments across a broader fund base.

In an environment that is evolving away from a public support model to follow more of a business model it is necessary to build decision support tools that enable people at multiple organizational levels to manage resources. In doing so, one of the key activities is to clearly understand the cost relationships between and among competing activities. These confounding factors of high labor costs relative to non-labor costs, high levels of fixed costs vs. variable costs and shrinking state support facilitate the need for improved understanding of cost relationships concerning the core academic mission of higher education.

Application of Activity-based Accounting Practices

One of the characteristics of higher education institutions is the high level of fixed costs relative to total costs. Estimates of fixed cost vary from 41% (used for grant processing- U. of Minnesota) to over 50% for other institutions(U. of Minnesota,1999). This high level of fixed costs requires some allocation or assignment of these costs to reflect the true costs of teaching and related activities. This assignment assists in determining pricing and other policies for these activities.

The solution to this high level of fixed costs relative to total costs is the application of activity-based accounting procedures(Hansen, 1997). The method consists of identifying activities that are an integral part of the primary activities of land grant institutions and major research universities which include teaching, research and public service. This paper will focus on teaching activities to the exclusion of the remaining items. Once activities are identified, the cost of these activities is enumerated. The next step is to assign activities to cost pools associated with major cost drivers. Part of this procedure is to calculate a cost rate associated with activities. The last step is to multiply the cost rate by the level of activity (using an allocation base such as hours of direct labor) to find the cost of activities.

This process will be illustrated relative to a specific course in the Department of Applied Economics. The course is Financial Accounting- ApEc 1251- with an enrollment of 85 students. Using the three credit designation, this course will generate 255 student credits hours. The specific costs of instruction include a portion of the tenured faculty members salary(allocated on the basis of the teaching portion of the A-appointment)- $11,760; $15,000 for space allocation-use of computer laboratory and classroom space(funded as a transfer or subsidy cost item);a portion of support staff time for teaching assistance; the service of a teaching assistant; variable costs which include paper , printing and other materials related costs; university-wide activities which include registration for course, sales of books and materials; specialized support costs of laboratories.

The process of identifying activities for ApEc 1251 is accomplished by enumeration. The following labor rates are thought to apply based on survey information.

Ordering text, materials planning	5 hrs @	$20/hr=	$100
Support staff time-exam, printing	15 hrs@	20/hr=	300
Copies and reproduction of teaching mat.	25 hrs@	20/hr=	500
Course registration	.25 hrs@	20/hr=	5
Bookstore, sale of materials	1.25hrs@	20/hr=	25
Computer maintenance & support	15 hrs@	30/hr=	450
Teaching preparation/Other hrs.	30 hrs@	30/hr=	1200
Room scheduling	.25hrs@	20/hr=	5
Teaching assistance time	100hrs.@	15/hr=	1500

Total			$4085

These activities were performed in support of instruction. Although this example enumerated the costs directly, other examples may calculate a cost rate and apply this rate to hours of direct labor expended in these activities(or an alternative measure of overhead- sp. ft of space devoted to activities).

The result of these calculations using activity based accounting methods is to generate a cost of the course at $15845 or $77 per student credit hour. It should be noted that this rate is above the university reimbursement rate of approximately $50 per SCH. Application of breakeven analysis using a rate of $179.70 per credit for tuition($539.10 for a 3 credit course) yields total revenue of $45823.00 for the course. Net revenue is $29978. Comparison of breakevens for similar courses would give a minimum enrollment level. Figure 1 shows the breakeven for this course.

Price and Income Elasticities for Higher Education

Hoenack and Collins(1991) discuss the literature of derivation of price and income elasticities of demand for higher education. The literature is clearly situational and a table is necessary to capture the range of estimates. Both equilibrium and nonequilibrium analysis are presented, as well as a range of type of institution. Most of the studies were completed in the early 1970's and 1980's. The most recent estimates are from the period of 1989 to 1992. Table 1 shows these estimates.

Table 1. Summary of price and income elasticities

Author /Study	Time period	Price Elasticity	Income Elasticity
Campbell/Siegel	1967	- .44	1.20
Calper & Dunn	1969		.69
Hight	1970	-1.058 Public U. -0.6414 Private U.	0.977 Public U. 1.701 Private U.
Hoenack (California U. system)	1984	-0.85 -1.12 -0.71	
Strom,Carter	1984	-0.46 two-year -0.77 four-year	
Lehr, Newton	1978	-0.6587	1.822
Cohn&Wagner	1978		0.965
Weiler	1984	-.5 to –1.0 Lower division -.25 Upper division 0.0 Graduate	

Hoenack and Weller in a California Study found that each $100 increase in tuition wuld reduce enrollment by 1.15% and .85% respectively. Hoenack also found that a $500 increase in scholarly aid would yield a 6-8 ½ % increase in applications(endowed funds) and 7-10% increase if tied to statutory monies.

It is also found that family income is inversely related to price responsiveness. A $100 increase in family income would decrease junior college rates by 7% and 0.60% respectively for the University of California(Hoenack and Collins, 1991).

The authors are planning to estimate price and income elasticities in the next phase of our project.

Estimate of Cost Functions for Colleges of Agriculture

A literature exists dealing with the estimation of cost function for higher educational and other institutions. One of the reasons for the authors' interest in this subject stems from inquiries as to cost efficiency and related matters within the past several years. Due to the regulatory status of nursing homes and the necessity to monitor rate increases based upon cost, a number of studies have examined cost relationships in nursing homes. One such study in Colorado using cross sectional data estimates several cost curves based upon quality-adjusted standard, which relates to level of skill nursing care. These functions were estimated with translog functional forms which impose the least restrictions based on functional form. Other studies in the literature find both linear and nonlinear forms are revealed in the data. The authors agree with quality-adjusted standards based upon qualifications of instructional faculty in an attempt to fairly compare cost relationships.

The literature on cost functions is summarized well by Brinkman which suggests assumptions that researchers should be aware of which are peculiar to higher education. One aspect is the very assumption that higher educational institutions seek to minimize costs. The reality for state-funded institutions is the amount of cost is related to the amount of expenditure funds available. In other words, the amount allocated will be spent. Legislative and other allocations would seem to be independent variables in a cost model. This is the revenue theory of cost advanced by Howard Bowen(1980). Another unique aspect is that higher education institutions produce more than one product. In a land grant institution such as the University of Minnesota and similar peer institutions, the overall mission prescribes teaching, research and public service. Cohn, Rhine and Santo(1969) examined higher education costs within a framework of joint production. Other studies used instruction, research and a measure of public service as variables in the cost equations. Case mix in health sciences and curricular emphasis are used in cost model design. The authors wish to perform similar analysis in the next part of this project. However, for the purposes of this study, the teaching activity will be singled out for analysis.

One of the reasons for estimation of cost functions is to determine the presence of economies of scale. The ratio of marginal cost to average cost is examined in this analysis. If the ratio is less than one, scale economies are present. If the ratio is greater than one, scale economies are absent. Studies indicate different results for ratios of marginal to average costs. Tierney(1980) found the ratio averaged 0.38 across seven academic departments. Brovender(1974) used a segregation of graduate and undergraduate populations at a large public research university. The ratio of MC:AC was estimated to be 0.53 for model 1 and 0.66 for model 2. Results varied from .72..81 in the social sciences to .49/.66 in humanities. These cost estimates are assumed to be short run estimates of cost as opposed to long run cost estimates. Razzi & Campbell(1972) estimated cost functions as six undergraduate colleges at a major public research university in which the ratio of MC:AC was 0.58 . A similar result was found in Great Britain.

Other studies by Brinkman(1981) found no evidence of economies of scale at twenty five major public research universities. Cohn, Rhine and Santo(1989) in a study of twenty one large universities indicate the greatest cost efficiency is achieved by institutions that have 30,000 full year equivalent students and $80-100 million in grants.

Brinkman(1981) suggests that" changes in marginal costs are negligible." In fact, some studies suggest that the difficulty of measuring marginal costs can be simplified by examined constant changes in average cost functions. This suggests linear shapes for some average cost functions.

There is considerable evidence that many different functional forms are potentially likely when performing empirical cost analysis. The preference for the translog function strongly suggests that this is the case.

The study at the College of Agricultural, Food and Environmental Sciences uses three different models for cost estimation. The first is a linear model of the form:

C= f(FYE, SCH, HEPI, Dummies92-00)

The estimated form is specified as follows:

C= 46545.5 + 2420.56 FYE + 39.934 SCH + 153809 d92-214234 d93 –19645 d94 –185030 d95 –140264 d96 –97365 d97 –64383 d98 –12271 d99 –85793 d00

The model has an adjusted R square of .774 with a standard error of 198719. The variable HEPI was dropped in successive iterations. The F ratio was 24.01 with a total of 11 d.f. used in regression and 77 d.f. in the residual.

The second model transforms variables into logs as follows:

C= f(log FYE, log SCH, log HEPI, dummies 92-00)

In statistical form, the equations becomes as follows:

C= 5.473 –1.932 FYE + 2.871 SCH -.123 D92 -.190 D93 -.130 D94 -.114 D95 -.154 D96 -.119 D97 -.045 D98 -.422 D99 - .506 D00

Variable 17(HEPI) was excluded in the analysis. The adjusted R square was .831. The F ratio was 34.47 with 11 d.f. used in regression and 77 d.f. in the residual.

The third model was a translog function of the form:

C= f(log FYE, log SCH, log HEPI, log FYE * log FYE, log SCH*log SCH, log FYE*log SCH, dummies 92-00)

In statistical form, the model can be rewritten as:

C= -3.082 -1.932 SCH * SCH +2.871 SCH*HEPI + .05 D92 -.023 D93 -.063 D94 -.081 D95 -.105 D96 -.108 D97 -.108 D98 + .339 D99

In the model, variables SCH, FYE, FYE squared, FYE*HEPI, HEPI and dummy for 00 were excluded.

The complete results are shown in Tables 2-4 for these individual regressions. The graphs in Tables 2-4 show the behavior of marginal and average cost over a range of assumptions for FYE and SCH with regard to the three models tested.

Summary

The comparison of the three models contains implications for economies of scale and other aspects of cost behavior. Most notably, the linear model does not show decreasing costs relative to either FYE or SCH. It appears that each additional FYE will increase cost by $2420, and each added SCH will increase cost by $39.93. This model shows constant average and marginal costs at the rates indicated. Using mean levels of FYE= 1000 and SCH=10000, the total cost using this function is $2420560 + 399340+ constant(46545.5)= $2866445.50. Since MC=AC in this example , scale economies do not appear to be present.

Examination of model 2 suggests that a curvilinear shape occurs. The negative coefficient on FYE at-1.932 implies decreasing cost per FYE when multiplied by log FYE. Each 100 FYE would decrease cost by 1.923* log(100)= ~$2.299 per FYE. The increase in SCH,however, would be 2.871 * log(1000)= $ 65.77 per 1000 SCH. This function implies that MC:AC would be less than one indicating some scale economies.

An analysis of the translog function- Model 3- suggests decreasing costs relative to SCH squared of a similar magnitude to that achieved in the previous model. The coefficient -1.93 * log SCH*SCH will decrease cost throughout the range, while the deflated SCH*HEPI shows increasing costs at 2.87 per deflated SCH. Again, the model shows the presence of some economies of scale.

Future research will look at a large sample of costs within similar Universities and the interrelationship of costs relative to teaching, research and public service. An observation by Hoenack relative to costs in relation to resources suggests that costs decline in periods of enrollment growth and rise in periods of enrollment decline. Also, the cost behavior varies by collegiate units and by discipline. Reasons for variations at the discipline level include price of inputs, input requirements (instruction) and the overall utilization of inputs.

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Table 2. Marginal and Average Cost- Linear Model

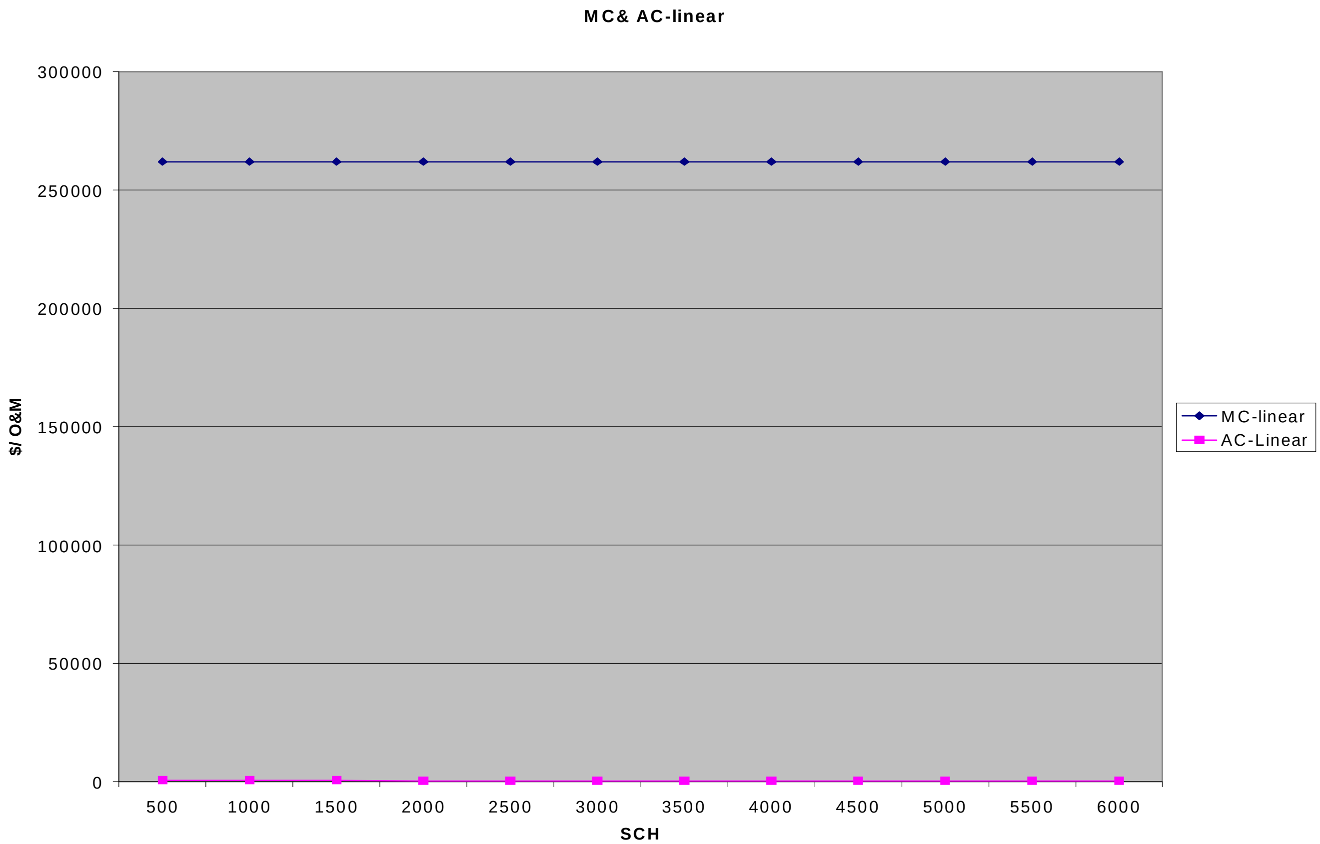

Table 3. Log Model- MC& AC

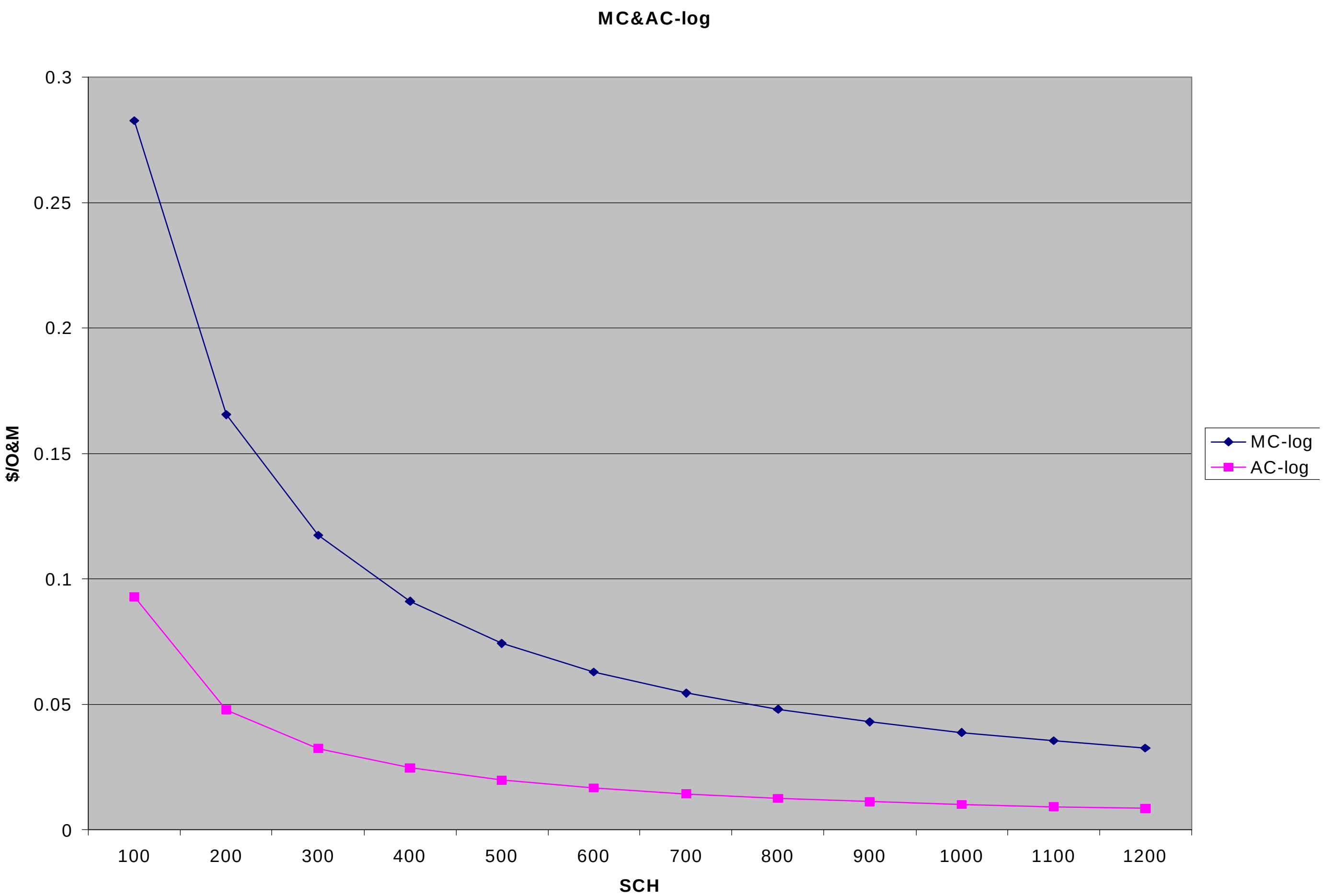

Table 4. Translog Model- MC& AC