Lancaster University
Management School

Costs, Efficiency and Economies of Scale and Scope in Higher Education Institutions

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Baumol (1982) - multiproduct organisations, economies of scale and scope.

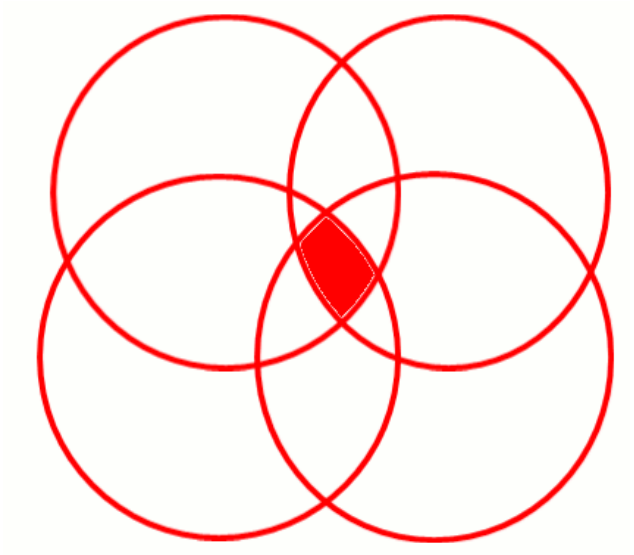
Cohn (1989) applied this to the context of higher education institutions.

Aigner (1977) introduced stochastic frontier analysis.

Lazarsfeld (1968) introduced latent class modelling.

multiproduct

education



stochastic frontier

latent class

Multiproduct organisations

Quadratic cost function

$$C_k = \alpha_0 + \sum_i \beta_i y_{ik} + \frac{1}{2}\sum_i \sum_j \gamma_{ij} y_{ik} y_{jk} + \sum_l \delta_l w_{lk} + \varepsilon_k$$

Average Incremental Cost: $$AIC(y_i) = [C(y_n) - C(y_{n-i})]/y_i$$

Ray economies of scale: $$S_R = \frac{C(y)}{\sum_i y_i C_i(y)}$$

Product-specific economies of scale: $$S_i(y) = AIC(y_i)/C_i(y)$$

Economies of scope: $$S_G = \left[\sum_i C(y_i) - C(y)\right]/C(y)$$

Stochastic frontier

$$C_k = \alpha_0 + \sum_i y_{ik} + \frac{1}{2}\sum_i \sum_j \gamma_{ij} y_{ik} y_{jk} + \sum_l \delta_l w_{lk} + v_k + u_k$$

v is the normal residual

u is a one-sided residual (half-normal) designed to capture observation-specific inefficiency

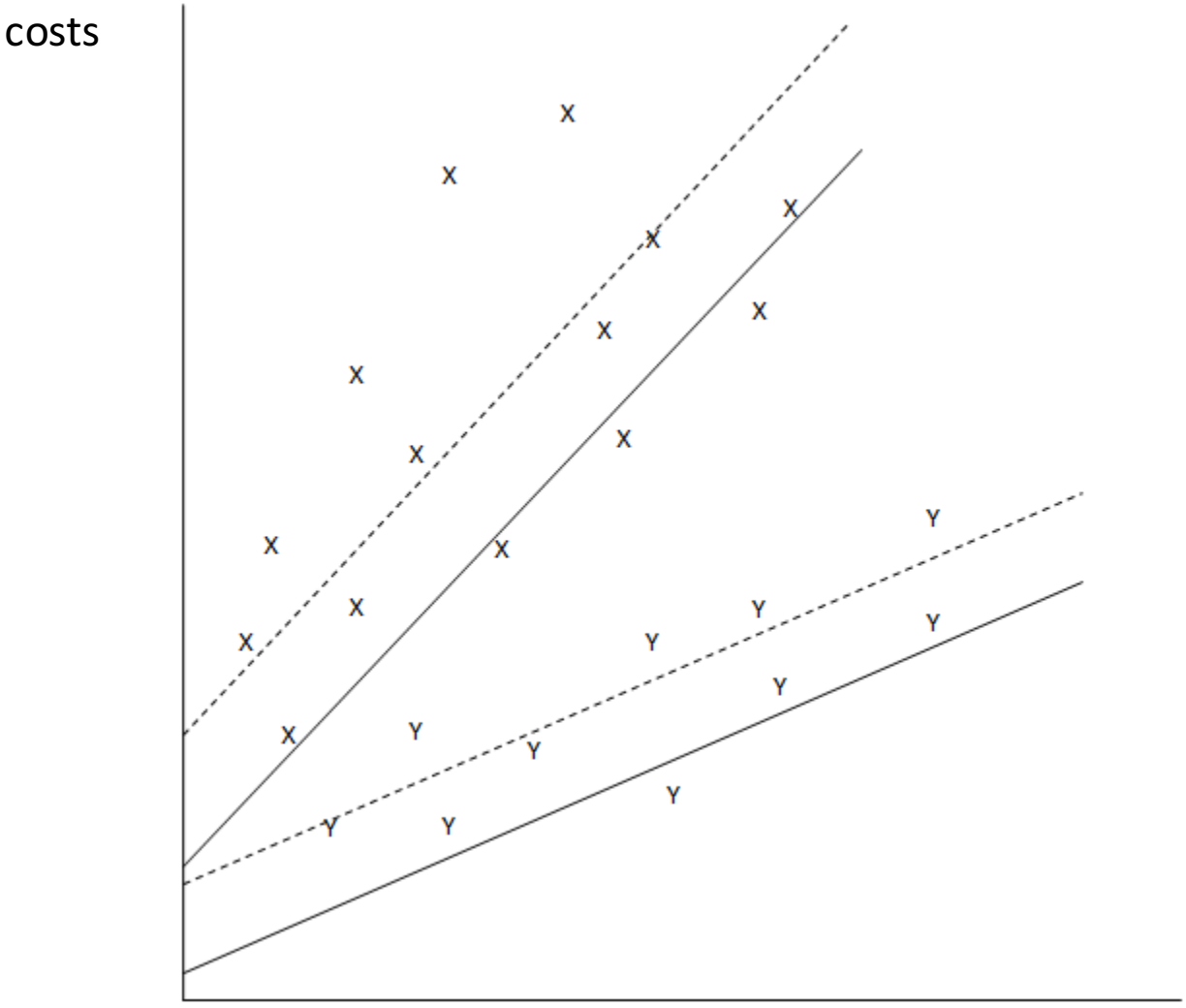
Estimated by maximum likelihood.

The observation-specific u terms can be retrieved using the method of Jondrow *et al*. (1982).

Latent class

$$C_{k,m} = \alpha_{0,m} + \sum_i \beta_{i,m} y_{ik} + \frac{1}{2} \sum_i \sum_j \gamma_{ij,m} y_{ik} y_{jk} + \sum_l \delta_{l,m} w_{lk} + v_{k,m} + u_{k,m}$$

Separate equation estimated for each latent class m, with observations grouped into latent classes by maximum likelihood.


costs
output

Data

HESA data, institutions in England, 2013-14. Excluding small institutions & Oxbridge.

Costs data include current expenditures, excluding 'hotel' costs.

Student data are full-time equivalent. For undergraduates, broad subject area (science v non-science) is identified. Finer disaggregation results in multicollinearity.

Research is measured by research income. This gives a 'market value' of research, appropriately weighting quantity and quality. It is highly correlated with REF income, and also with bibliometric measures.

Input prices are measured by hedonic wages. These are in turn evaluated as the residual from a regression of wage bill against staff numbers in each of ten age groups.

Controls considered but not used: real estate area comprising listed buildings; income from intellectual property; student numbers from disadvantaged postcodes.

Results

	SFA	SFA Latent class 1	SFA Latent class 2
Constant	-8.296	36.179	5.526
	(6.99)	($573x10^5$)	(5.36)
Undergraduates: non-science (UGA)	4.727**	1.990	4.553*
	(2.27)	(4.93)	(2.45)
Undergraduates: science (UGS)	8.020***	5.065	4.067
	(2.25)	(6.05)	(2.59)
Postgraduates (PG)	27.030***	16.450	19.118***
	(4.60)	(18.03)	(7.38)
Research (RES)	1.877***	2.365**	1.664***
	(0.18)	(1.09)	(0.21)
UGA2	-0.069	0.217	0.023
	(0.31)	(0.76)	(0.31)
UGS2	0.768*	0.003	0.498
	(0.40)	(1.14)	(0.49)
PG2	-1.252	2.592	-3.653
	(1.33)	(4.32)	(3.55)
RES2	-0.007***	0.004	-0.008**
	(0.00)	(0.01)	(0.00)
UGA*UGS	-0.616	0.014	-0.220
	(0.63)	(1.51)	(0.57)
UGA*PG	2.014	-1.199	0.622
	(1.53)	(4.28)	(1.93)
UGA*RES	-0.084	0.176	-0.061
	(0.05)	(0.22)	(0.07)
UGS*PG	-2.840**	0.843	0.893
	(1.17)	(3.29)	(1.52)
UGS*RES	0.118***	-0.025	0.005
	(0.05)	(0.17)	(0.08)
PG*RES	0.224**	-0.284	0.398*
	(0.10)	(0.43)	(0.22)
Hedonic wage costs	0.507*	0.797*	0.222
	(0.27)	(0.48)	(0.31)

Descriptives

	Latent class 1		Latent class 2	
	mean	SD	mean	SD
Cost	193.443	123.661	184.298	205.650
Undergraduates, science (thou)	4.938	2.648	5.078	3.997
Undergraduates, other (thou)	6.029	2.955	5.819	3.530
Postgraduates (thou)	2.579	1.410	2.536	2.465
Research (mill)	23.045	43.774	28.784	58.878
	Mainly 94 Group & large ex-polys		Mainly Russell Group & small specialist institutions	
Number in class	54		49	

Average Incremental Costs

	SFA	SFA LC1	SFA LC2
Undergraduate sciences	4000	6763	7726
Undergraduate other	4232	4337	3401
Postgraduate	27322	13533	29474
Research	2.36	2.67	2.11

Returns to Scale

	SFA	SFA LC1	SFA LC2
Undergraduate sciences	0.51	1.00	0.75
Undergraduate other	1.11	0.77	0.96
Postgraduate	1.13	0.67	1.46
Research	1.08	0.97	1.13
Ray returns	0.97	1.06	0.94

Returns to Scope

	SFA	SFA LC1	SFA LC2
Undergraduate sciences	0.23	0.14	-0.00
Undergraduate other	0.00	0.15	0.08
Postgraduate	-0.05	0.31	-0.27
Research	-0.10	0.16	-0.17
Global returns	0.04	0.57	-0.10

Robustness check

Linear three latent class model - (a quadratic three class model does not converge)

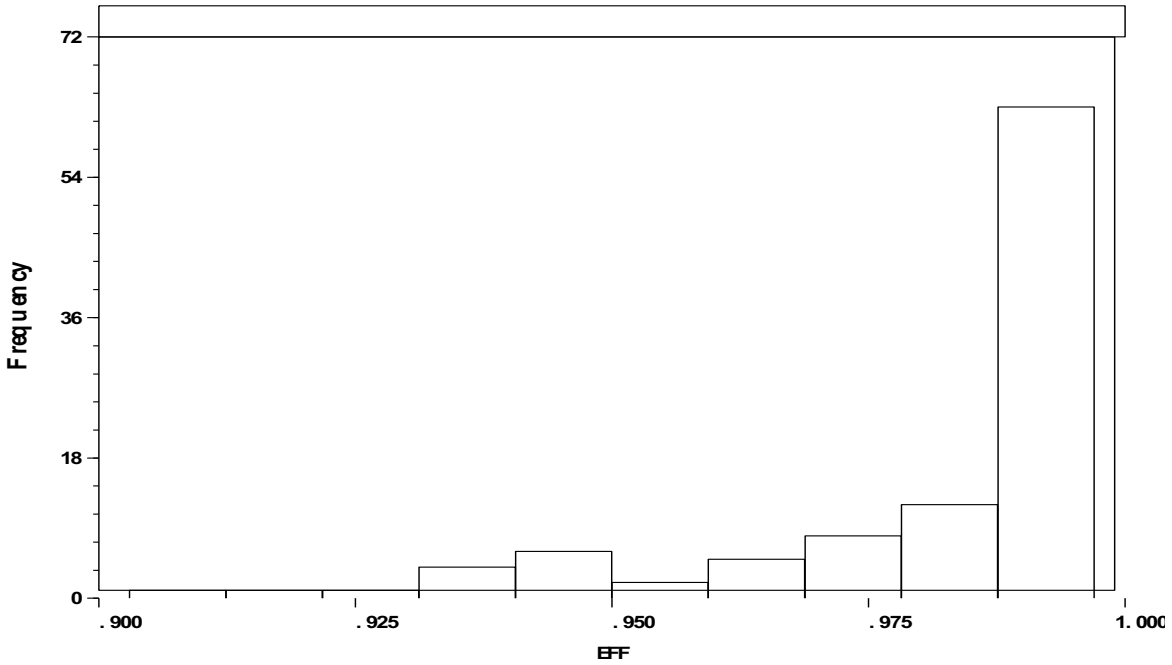
Table A1: Average incremental costs (AICs) by class

	Latent class 1	Latent class 2	Latent class 3
Undergraduate sciences	7869	9245	8463
Undergraduate other	5784	4166	1415
Postgraduate	16973	22641	31908
Research	2.71	1.90	1.65

Table A2: Descriptive statistics of variables by latent class

	Latent class 1		Latent class 2		Latent class 3	
	mean	SD	mean	SD	mean	SD
Cost	153.925	134.983	253.919	240.000	244.055	145.395
Undergraduates, science (thou)	4.584	3.391	6.524	3.196	4.834	2.978
Undergraduates, other (thou)	5.873	3.309	7.025	3.270	4.916	2.608
Postgraduates (thou)	2.104	1.590	3.174	2.547	3.515	2.092
Research (mill)	15.109	30.124	48.265	91.856	39.304	41.735
	small institutions		large research intensives		other large institutions	
Number in class	65		20		18	

Efficiencies



Conclusions

Latent class approach picks up unobserved heterogeneity.

PG provision is costly – especially so in Russell Group and specialist institutions (LC2).

There are unexhausted product-specific economies of scale in institutions in LC2.

There are unexhausted economies of scope in LC1.

There are high levels of efficiency.