Measuring Baumol and Bowen Effects in Public Research Universities

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Abstract

Using the coefficients estimated in our cost model we deconstruct real cost changes per student between 1987 and 2008 and between 2008 and 2010 into Baumol and Bowen effects. We find for every $1 in Baumol effects there are over $2 in Bowen effects. Tight revenue since 2008 reversed the previous decline in productivity and accelerated the trend in economizing on the use of tenure-track faculty. This behavior under loose and tight revenue constraints is consistent with Bowen's Rule. The model suggests the optimal staffing ratio is over two tenure-track faculty members per full-time administrator, while the current average ratio is two full-time administrators for one faculty member.

1. Introduction

Over the past three decades, increasing college costs[1], declining undergraduate value added[2], and ballooning student loans[3] became important public policy issues and these concerns are made more acute by declining household income, federal/state deficits, looming entitlement deficits, and seriously underfunded public pension obligations. Controlling college cost is now a priority, lest college costs further reduce economic mobility.

"Baumol's Cost Disease[4]" and "Bowen's Rule[5]" are the most prominent higher education cost theories[6]. Baumol's cost disease argues costs rise due to external macroeconomic forces, while Bowen's rule claims cost increases are due to decisions taken inside higher education.

Baumol's cost disease is the disproportionate tendency of costs to rise in labor-intensive service industries. Increasing productivity in the macro-economy causes a general increase in real wages and those wages draw productive workers from service industries forcing them to raise wages even though productivity has not increased. The combination of fixed productivity and higher wages must lead to higher cost. Higher education insiders frequently argue government mandates and the Baumol effect are the source of higher education's chronic cost problem (Baumol and Batey-Blackman, 1995).

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[1] See Martin (2011) or Massy (2003), among others.

[2] See Bok (2005), Hersch and Merrow (2005) or Arum and Roksa (2011).

[3] See FRBNY (2012) and Parsons and Hennessey (2012).

[4] See Baumol and Bowen, W G, (1966).

[5] See Bowen, H R, (1980).

[6] In addition to Baumol and Bowen's theories there are two other cost drivers, government mandates and bundling services not previously associated with higher education. Government mandates are an external source of cost increases and bundling is an internal source of cost increases.

Bowen's rule[7] states universities raise all the money they can and then spend it on an unlimited list of projects that seemingly enhance "quality." Essentially, the rule says revenue drives cost. The components of Bowen's rule are break-even budgeting, the peculiar economics of experience goods, and unresolved agency problems (Martin, 2011). Since reduced productivity can be taken as agent rents, Bowen's rule implies staff/student ratios are flexible on the upside, rather than fixed as is implied by Baumol's cost disease. In other words, insiders can take rents through reduced productivity.

Bowen identifies periods when revenue constraints were "tight" and when they were "loose;" from 1929 to 1950 cost per student declined, from 1950 to 1970 cost per student rose rapidly, and from 1970 to 1980 cost per student declined slowly (Bowen, 1980, 29-47). The degree of revenue constriction is determined by economic conditions and how the public values higher education. The period from 1980 to 2008 is known as the "great moderation," when economic conditions were quite good and, according to surveys, the public placed an ever higher value on postsecondary education. Post 2008, economic conditions are severe and the public is pressed by the cost of higher education, also supported by surveys. Our new data covers 1987 to 2010, so it provides a natural experiment for testing Bowen's rule under "loose" and "tight" revenue constraints.

Both the Baumol and Bowen theories have sound economic foundations, so we expect each contributes to rising cost. Therefore, the issue is an empirical question: Which theory has the larger impact on higher education costs? Our goal is to deconstruct real cost changes from 1987 to 2008 and from 2008 to 2010 into Baumol effects (outside factors) and Bowen effects (internal decisions). Since reform depends on the answer to this empirical question, it is an important policy issue.

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[7] The rule is derived from Bowen's five laws: 1) "The dominant goals of institutions are educational excellence, prestige, and influence;" 2) "there is virtually no limit to the amount of money an institution could spend for seemingly fruitful educational ends;" 3) "each institution raises all the money it can;" 4) "each institution spends all it raises;" and 5) "the cumulative effect of the preceding four laws is toward ever increasing expenditure" (Bowen, 1980, 19-20).

In the next section we review the traditional estimation of education cost functions and argue cost models without controls for staffing patterns suffer from omitted variable problems; that is, Bowen's rule suggests staffing patterns should be included in higher education cost equations. The data are reviewed in the third section and the governance hypothesis is explained in the fourth section. The governance hypothesis argues that shared governance lowers higher education costs, while the withering away of shared governance increases cost[8]. A total cost model is presented and estimated in section five and six, where the significance of staffing patterns is demonstrated, the governance hypothesis is tested, and other results are reported[9]. In section seven, we deconstruct the actual changes in cost per student from 1987 to 2008 and from 2008 to 2010. We find that Bowen effects under both loose and tight revenue constraints are larger than Baumol effects and that for every $1 in increased cost due to Baumol effects there are between $2 and $3 in Bowen effects. Post 2008, the model suggests universities shifted from selective cost saving to across the board cost saving and intensified their traditional cost saving.

2. Estimating Higher Education Cost Functions.

Traditionally higher education cost studies assume either costs are minimized (Cohn, et al., 1989) (Cohn, et al., 2004) (Johnes, et al., 2008) (Johnes, et al., 2009) or costs are not minimized (Newhouse, 1970) (James, 1978) (Brinkman, 1989, 1990) (Clotfelter, et al., 1991) (Ehrenberg, 2000). If costs are in

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[8] See Ginsberg (2011).

[9] In an earlier version of this paper we estimated reduced form equations for academic cost and overhead costs and for total cost. We added another year of observations (2010) and the revenue variables to the sample for this version. We find the critical results with respect to the governance hypothesis and Baumol/Bowen effects are the same as those reported in the earlier version: adding more data and more control variables did not change the results. In the interest of space we do not report the results from the academic and overhead reduced form models in this new version of the paper. These results are available on request.

fact minimized, the duality conditions allow one to uncover properties of the production function from the estimated parameters and the only data required are cost, output, and input prices (Mas-Colell, Whinston, and Green, 1995, 139-143). Staffing patterns would not be needed.

In "for profit" industries, cost minimization is a reasonable assumption, since cost minimization is a necessary condition for profit maximization. In a non-profit environment, however, it does not necessarily follow that costs are minimized.

Bowen's rule is based on break-even budgeting, complex experience goods, shared governance, and unresolved agency problems (Martin, 2011). The break-even revenue constraint leads to competition among agents for a fixed quantity of funds during each budget cycle. If agents collude to maximize rents and then distribute those rents there would be little conceptual difference between profit maximization and rent maximization, costs would be minimized, and the duality conditions would hold[10]. This is not what happens, however; rent seeking behavior in higher education leads agents to take rents in the form of higher expenditures within the areas they control. Therefore, rents are mixed with legitimate expenditures and this makes economic costs indistinguishable from rents[11].

When rents are taken as expenditures, the cost allocation depends on the relative number and importance of the agents in the organization. Costs cannot be unpacked unless one examines staffing patterns. Hence, an empirical cost function that contains only output and input prices has omitted variable problems. Specifically, the cost model should control for staffing patterns across different constituencies in the institution. Alternatively, if higher education costs are minimized, the cost function

[10] It would be impossible to pursue such an agency agenda, since rent distribution would leave an obvious audit trail. Mixing legitimate expenditures with rents makes it very difficult for the principal to monitor the agents' behavior.

[11] By contrast, rents are separated from costs by for-profit accounting.

should be independent of staffing patterns. As we find, the staffing variables are individually and collectively significant in the estimated cost function.

3. Data

The data are drawn from the National Center for Education Statistics' IPEDS website, it covers 137 Carnegie[12] I and II public research universities, for the academic years 1987, 1989, 1991, 1999, 2005, 2008, and 2010. There are 982 usable observations in the estimating sample[13]. Our objective is to explain variations in costs between public research universities and across the time period studied; in general, these costs will be driven by decisions taken by each institution regarding academic and overhead staffing patterns, salaries paid, the nature of the undergraduate/graduate programs offered, and the size and composition of the institution's enrollment. Costs are also thought to be influenced by locations, both urban/rural and regional, Carnegie classification, and the emphasis placed on different types of graduate programs.

The variables. The cost[14] variables are real total cost per student (*tc*), real academic cost per student (*ac*) and real overhead cost per student (*oh*). Academic costs[15] include instruction, research, and

[12] Carnegie I is classified as "very high research activity" and Carnegie II is "high research activity." There are 146 institutions in this classification. However, usable information was available for only 137 institutions.

[13] There are two data samples in this study. The first is the estimating sample which contains 137 institutions and 981 usable observations for the period studied. This sample is used in the estimation of the cost equations. The second sample is the cost analysis sample which contains 133 institutions and 812 usable observations. The cost analysis sample is smaller than the estimating sample because the partial differential method for deconstructing the cost changes requires that for each 1987 observation there must be a matching 2008 observation and a matching 2010 observation. Only 133 institutions provided usable data in all years.

[14] Between 1987 and 2010 these institutions adopted significant accounting changes. These changes make it difficult to get consistent time series data on cost. The most consistent total cost series are "total current funds expenditures and transfers total" for 1987 and "total operating expenses – Current year total" for 2010. Using "total educational and general expenditures and transfers total" for 1987 tends to significantly understate the overhead cost in 1987, leading to an overstatement of the total change in overhead spending from 1987 to 2010.

public service; while overhead costs include all costs from academic support, student services, institutional support, plant operation/maintenance, auxiliary activities, hospitals, and independent operations. Enrollment is measured by FTE students (*ftestu*), the number of full-time undergraduate students (*ftug*), the number of full-time graduate[16] students (*ftgrad*), and the number of part-time students (*ptstu*).

Faculty staffing is measured by the number of tenure-track faculty per 100 students (*tt*), the number of contract faculty per 100 students (*cf*), the number of part-time faculty per 100 students (*ptf*), the number of FTE faculty per 100 students (*ftef*), the number of teaching assistants per 100 students (*ta*), and the ratio of tenure-track faculty to full-time non-academic professional employees (*ttad*). Full-time non-academic professional employees include executives, managers, and other professional staff. FTE staff salaries are the total salaries and wages paid divided by the number of FTE staff employed (*staffsal*). Full-time employee benefits are measured by total benefits paid divided by full-time staff members (*benstaff*).

Non-instructional staffing is measured by the number of FTE executive/managerial employees per 100 students (*fteex*), the number of other FTE professional employees per 100 students (*ftepro*), and the number of FTE non-professional employees per 100 students (*ftenpro*). The composite variable, *fteadmin*, is the number of FTE executive and professional employees per 100 students. The average number of "reports" per executive is measured by the sum of all FTE professional administrators and all FTE nonprofessional staff divided by the number of FTE executives/managers (*staffsize*). Part-time

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[15] Some researchers claim student service cost should be included in academic costs. Student service staffing expanded rapidly from 1987 to 2010 and student service professionals claim it is their responsibility to take over "instruction outside the classroom." The nature of these activities and the academic qualifications of student service personnel make this notion arguable at least. What is clear is that the inclusion of student service in academic cost will significantly understate the growth in overhead if it is included in academic cost.

[16] The number of graduate students includes graduate and professional students as well.

staff employment is measured by the number of part-time administrators per 100 students (*ptadmin*), and the number of part-time non-professional staff per 100 students (*ptnpro*).

Carnegie I research institutions are identified by the dichotomous variable *carnegie*, institutions that emphasize the STEM[17] disciplines are identified by *stem*, institutions with medical schools or veterinary schools are identified by *medical*, and institutions that emphasize professional schools are identified by the variable *prof*. The dichotomous variables for different geographic regions are the far west coast (*fwest*), New England[18] (*neweng*), and the Great Lakes (*glakes*).

By Bowen's Rule, revenue caps total cost and higher revenue drives cost higher; hence, we expect total cost per student to rise as revenues per student increases. We divide total revenue into operating revenue (*rev*) and investment income (*invest*) per student. Further, we separate operating revenue into core revenue (*core*), donor revenues (*donor*), hospital revenue (*hosp*), and all other operating revenue (*other*). Core revenue is tuition/fees, room/board, and all government appropriations. Other revenue includes grants and other operating revenue. All revenue variables are real revenue per student from the prior year.

Staffing Variables. IPEDs data contains considerable detail on the number of faculty and their salaries by rank, ethnicity, race, or gender. By contrast, there is little salary data for executive/managerial, professional, and non-professional staff and no detail about the number of staff employed in different functions for executive/managerial and professional staff. Non-professional staff is classified by clerical, skilled, technical, and maintenance.

The asymmetric treatment of faculty/non-professional staff versus executive/managerial and professional staff creates problems for our analysis: we cannot definitively separate the number of

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[17] STEM means science, technology, and mathematics.

[18] This variable includes both the New England states and the mid-Eastern states.

professional academic support staff versus the number of professional administrative support staff; nor, do we know how many professional staff positions are due to government mandates. As a consequence, the *fteadmin* variable includes academic support staff as well as purely administrative support staff. On the other hand, the tenure-track faculty variable (*tt*) includes all tenure-track employees, some of whom hold administrative posts and are not engaged in teaching or research.

The asymmetric treatment of faculty versus administrator counts and salary data has persisted for over three decades. Among charitable organizations, efficiency is measured by the "activity ratio;" for higher education the activity ratio is the academic share of total cost. The absence of accurate administrator numbers and salary data makes it impossible to calculate an accurate activity ratio for higher education; at the very least, this is a major regulatory oversight by the Department of Education. In any event, these are the inherent limitations in the IPEDS data set.

Data Table 1. A summary of change in the estimating sample[19] between 1987, 2008, and 2010 is contained in Table 1. All dollar denominated variables are in real terms. The average values are weighted[20] by enrollment. All growth rates are measured as average annual growth rates.

The data reveals that academic cost, overhead cost, and total cost per student increased by 1.8 percent, 2.5 percent, and 2.1 percent per year, respectively, from 1987 to 2008. Academic activities' share of the total budget declined slightly from 49 percent to 48 percent. These trends were abruptly reversed after 2008 when academic cost, overhead cost, total cost, and academic share changed by 8.2 percent, −6.1 percent, 0.5 percent, and 7.5 percent per year, respectively. Academic share increased dramatically while total cost continued to increase from 2008 to 2010.

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[19] See footnote 11.

[20] The weight is the fraction of the institutions share of total enrollment for that year.

From 1987 to 2008, average enrollment increased by 1.4 percent per year, the number of full-time undergraduate students increased by 1.4 percent per year, the number of full-time graduate students increased by 1.9 percent per year, and the number of part-time students declined by 0.7 percent per year. Overall, these institutions increased in size, became more graduate intensive and less dependent on part-time students. As one would expect, enrollment growth accelerated for FTE students and full-time undergraduate and graduate students from 2008 to 2010.

The number of FTE faculty per 100 students increased by 0.6 percent per year, tenure-track faculty increased by 0.2 percent per year, and part-time faculty increased by 2.7 percent per year from 1987 to 2008. The contract faculty ratio increased by 1 percent per year over that period. Since the tenure-track ratio was almost constant while the contract faculty ratio and the part-time ratio increased substantially, these institutions invested more intensively in contract and part-time faculty from 1987 to 2008. From 2008 to 2010, FTE faculty declined by 1.9 percent per year, tenure-track faculty declined by 1.5 percent per year, and part-time faculty declined by 18.1 percent per year, while contract faculty grew by 1.7 percent per year and teaching assistants grew by 11 percent per year. The period from 2008 to 2010 represents an acceleration of the conservation trend in teaching resources.

From 1987 to 2008, full professor salaries increased by 0.9 percent per year and assistant professor salaries increased by 0.7 percent per year. In contrast, average FTE staff salaries (the average for all staff – both teaching and non-teaching) increased by 2 percent per year, more than double the rate of increase in full professor salaries. Benefit costs (*benstaff*) increased by 4.6 percent per year from 1987 to 2008. From 2008 to 2010, full professor salaries increased by 0.5 percent, assistant professor salaries increased by 0.6 percent, and staff salaries increased by 2.4 percent per year. The professorial salaries declined from trend, while the staff salaries rose from trend. The average annual rate of growth in benefits also rose from trend in the 2008 to 2010 period.

For salary comparisons, median household income increased by 0.3 percent per year from 1987 to 2008 and declined by 2.5 percent per year from 2008 to 2010. In 1987, the upper income limit for the third quintile in the income distribution was $57,798, less than the average assistant professor salary of $59,205. Assistant professors were in the fourth quintile in 1987 and their salary was equal to 68 percent of the upper bound for the fourth quintile. The average assistant professor salary remained at 68 percent of the upper bound in 2008. The average full professor salary was in the top income quintile in 1987 and was 108 percent of the upper bound for the fourth quintile. In 2008, the average full professor salary was 112 percent of the upper bound for the fourth quintile. The BLS Employment Cost Index (BLS, 2012) for service industries increased by 116 percent from 1987 to 2008, in line with the increase in *benstaff*.

The staffing patterns for non-instructional staff are rather different than the academic staffing patterns. FTE executive/managerial staff per 100 students increased by 0.3 percent per year, FTE professional staff per 100 students increased by 2.6 percent per year, and FTE non-professional staff per 100 students declined by 1.4 percent per year for the period from 1987 to 2008. The staff size variable increased by 0.4 percent per year, reflecting an increase in the number of “reports” per executive (each executive’s professional staff tended to get larger). Since the number of non-professional staff declined, there was a significant increase in the size of each executive/manager’s professional staff. For the 2008 to 2010 period, FTE executive/managerial staff, professional staff, and non-professional staff declined by 2.9, 0.9, and 4 percent per year, respectively. There was a significant break from trend in the latter period. After 2008, universities began to reduce cost across all administrative positions and they economized more intensively on all teaching/research staff.

With respect to all the foregoing staffing ratios, it is important to remember they are defined as the number of staff members per 100 FTE students; hence, the number of staff members has to grow faster than the number of students in order for those ratios to rise. This means the actual number of staff members is growing faster than the number of students when the ratio rises. For example, from 1987 to 2008, the number of tenure-track faculty and the number of FTE faculty grew by 33 and 45 percent respectively, while the number of FTE executive/managerial and FTE professional grew by 37 and 99 percent and FTE non-professional declined by 9 percent. In 2008, there were 961 tenure-track faculty and 2029 FTE administrators at the representative university.

From 1987 to 2008 and from 2008 to 2010, total operating revenue per student increased by 2.4 percent per year. From 1987 to 2008, core, donor, hospital, and other operating revenues increased by 0.7, 7.9, 3.6, and 5.8 percent per year, respectively. From 2008 to 2010, core, hospital, and other revenues increased by 0.4, 11.9, and 14.6 percent per year, respectively, while donor revenue and investment income declined by 34.3 and 87.6 percent per year. The donor and investment declines reflect the market crash that followed the financial crisis.

The staff changes after 2008 are cost cutting efforts for all types of staffing; this is consistent with Bowen's description of university behavior under tight revenue constraints and loose revenue constraints. "Within wide limits, institutions can adjust to whatever amount of money they are able to raise. When resources are increased, they find uses for the new funds, and unit costs go up. When resources are decreased, they express keen regret and they protest, but in the end they accept the inevitable, and costs go down. This set of generalizations might be called the *revenue theory of cost*" (Bowen, 1980, 15).

4. The Governance Hypothesis

Since agency problems always result in costs higher than necessary, higher education's cost history from 1987 to 2008 is an agency problem's latent print. Therefore, an important empirical task is to identify the core agency problem: is it pampered tenure-track faculty, empire building administrators, or both agent groups? The natural constraints on agency abuse in corporations and in politics are the market for corporate control and elections; the shared part of shared governance is the only natural constraint on agency abuse in higher education.

The forgoing suggests three competing *governance hypotheses:* The *tenured faculty,* the *spendthrift administrator,* or the *shared governance hypotheses.* The tenured faculty hypothesis holds that powerful tenure-track faculties prevent cost conscious administrators from controlling cost. An equally viable hypothesis is the cost problem originates with spendthrift administrators, since they have de facto control over spending. If either the tenured faculty or spendthrift administrator hypotheses are true, the solution is to adopt incentive compatible contracts or constraints on adverse agency behavior for the offending agent group. The shared governance hypothesis[21] holds that both agent groups are the problem and a partial solution is to balance their respective pursuit of self-interest through a stronger shared governance contract between faculty, administrators, and governing boards. Benjamin Ginsberg's (2011) "rise of the all-administrative university" is consistent with either the spendthrift administrator or the shared governance hypothesis. The shifts in staffing patterns from 1987 to 2008 are consistent with an administrator induced cost problem.

Generally, the budgetary outcome will depend on the size and influence of each constituent group. Since part-time employees and non-professional employees have little influence on resource decisions, their preferences are unlikely to be decisive. The most influential agents are tenure-track faculty and full-time professional administrators. In 1987 the ratio of tenure-track faculty to full-time

[21] Beyond the absence of mechanisms similar to markets for control and elections, higher education is subjected to little federal regulation of agency issues, there are no third party groups with a financial interest in monitoring higher education, the press has little appetite for HE agency stories, and the public believes they have charitable motives since they are non-profits.

administrators in our sample stood at 1; by 2008 that ratio fell to 0.6. It declined slightly in 2010. Today tenure-track faculty members are outnumbered by administrators. The decline in *ttad* occurred steadily over the period from 1987 to 2008. The ratio (*ttad*) is a natural metric for the relative bargaining strength between academic interests and administrator interests in the annual budget cycles.

If the cost problem is primarily due to the tenured faculty hypothesis, then the marginal effect of *ttad* should be positive; costs should rise as *ttad* increases. If the cost problem is primarily due to spendthrift administrators, then the marginal effect of *ttad* should be negative. Finally, if shared governance is an effective constraint on agency abuse from all parties, cost should be a convex function of *ttad*; an optimal ratio should exist and an imbalance either way should lead to higher costs.

5. Model Specification

For Total Cost (*tc*) we specify the log-linear regression

$$\ln\left(tc_{it}\right) = \beta' x_{it} + \alpha_i + u_{it} \tag{1}$$

where α_i are individual effects, with $i = 1,\ldots,n$ and $t = 1,\ldots,T_i$. The least squares, random effects and fixed effects parameter estimates are reported in Table 2. The OLS estimates are reported in the first column, random effects estimates[22] in the second column, random effects estimates with robust cluster standard errors in the third column, fixed effects estimates in the fourth column and fixed effects estimates with robust cluster standard errors in the fifth column. For the purpose of "deconstructing costs," and the results in Table 3 of the paper, the parameters β are estimated using fixed effects since the Hausman test rejects the null hypothesis that the regressors and random effects are uncorrelated in each equation.[23] The parameter estimates are denoted $\hat{\beta}$. We employ robust cluster-corrected covariance

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[22] All model estimations are carried out in Stata 12.1

[23] This conclusion was drawn on the basis of the usual contrast tests under the assumption of homoscedasticity (no clustering), and also the regression based Hausman test describe in Wooldridge (2010, 332). In this test the averages of the

matrix estimates $\hat{V}$, because some residual correlation across time remains even after including year dummies.[24] We then employ the partial differential approach to quantify the Baumol and Bowen effects in the next section.

The omitted faculty staffing ratio is the tenure-track/student ratio; hence, the interpretation is, holding *ftef* constant an increase in *cf* or *ptf* represents a substitution for tenure-track faculty. The expectation is the signs of *cf* and *ptf* should be negative, since they are a lower cost alternative to tenure-track faculty. Similarly, holding *cf* and *ptf* constant an increase in *ftef* represents an increase in tenure-track faculty. Therefore, the sign of *ftef* should be positive.

The omitted administrator staffing ratio is the full-time administrator/student ratio. Hence, holding *fteadmin* constant, an increase in *ptadmin* represents a substitution of part-time employees for full-time employees, suggesting the coefficient should be negative since part-time employees do not receive benefits. The same interpretation applies to the inclusion of *ftenpro* and *ptnpro*. The coefficient for *ftenpro* should be positive and *ptnpro* should be negative. The variable *staffsize* is a metric for overhead staff sizes, suggesting its coefficient should be positive, since *staffsize* equals the sum of *ftepro* plus *ftenpro* divided by *fteex*.

Scale effects are measured by *ftestu.* The mix between undergraduate and graduate programs is controlled for by *ftgrad*, *ftestu*, and *ptstu;* holding *ftestu* and *ptstu* constant an increase in *ftgrad*

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time varying variables are added as regressors in a random effects estimation and their significance jointly tested based on a cluster corrected covariance matrix. Using not only the complete set of time varying variables, but also various subsets of those variables, we reject the null hypothesis that the heterogeneity is not correlated with the time averages. Augmenting the regression with the time averages of regressors, Mundlak's (1978) approach, and applying random effects [Greene, 2012, 381; Wooldridge, 2010, 332] offers no meaningful gain in efficiency. The standard form of the more general correlated random effects model of Chamberlain (1982) [Greene, 2012, 383; Wooldridge, 2010, 347-349] does not apply since our panel is unbalanced.

[24] The data used are not equally spaced through time. We have data from 1987, 1989, 1991, 1999, 2005, 2008 and 2010. For each equation, using the fixed effects residuals, we regress the residuals in time t against the residuals in time $t-1$, both with and without other regressors, for each year. These tests are described in Wooldridge (2010, 310-311). While not every pair of years produced significant evidence of serial correlation, it was significant in more estimations than not. This justifies the use of fixed effects estimation with cluster corrected covariance matrix.

represents a substitution of one full-time graduate student for one full-time undergraduate student. Other things equal, an increase in *ftgrad* represents an increase in graduate intensity and it should increase costs. Holding *ftgrad* and *ptstu* constant, an increase in *ftestu* should reduce costs due to both scale effects and program mix effects. The variable *ta* is the number of teaching/research assistants per 100 students; hence, it is a control for the intensity of PhD programs on campus. On the other hand, if teaching assistants replace contract faculty or part-time faculty, costs may decline as *ta* increases. Therefore, the expected sign of *ta* is ambiguous.

Bowen's revenue theory of cost suggests the signs of operating revenue and investment income should be positive. We include *rev*, *donor*, *hosp*, and *other* in the equation excluding *core* revenues; therefore, holding *rev* constant the interpretation is an increase in *donor*, *hosp*, or *other* represents a replacement of $1 in core revenue with $1 from one of those sources. If $1 of increased revenue from any of these sources has the same Bowen effect on cost, the coefficients should be insignificant.

6. Estimation Results.

Results using fixed effects estimation are contained in column (5) of Table 2[25]. The coefficients for *cf*, *ftef, ptstu, ttad, ttad2, fteadmin, fteadmin2, ftenpro, staffsal, staffsize, d1999, d1991, d2005, d2008,* and *d2010* are statistically significant using a two-tail test at the 0.01 or better level and have the anticipated signs. The coefficients for *ptf, ftgrad, rev,* and *d1989* are statistically significant using a two-tail test at the 0.05 or better level.

The signs for *ttad* and *ttad2* suggest total cost is convex in *ttad* with an estimated turning point at 3.1 with 95% interval estimate [2.49, 3.66]. The elasticities of total cost at the quartiles of *ttad* are

[25] Fixed effects estimates obtained using XTREG, FE in Stata 12.1. Standard errors are based on a cluster corrected covariance matrix, which is used because some significant serial correlation remains even with year dummies.

−0.072, −0.092 and −0.112, respectively.[26] The tenure-track faculty hypothesis is rejected, while the spendthrift administrator and shared governance hypotheses are consistent with the data. These results are robust to the estimation method used, the addition of new data, change in specification, and Carnegie classification.

The signs for *fteadmin* and *fteadmin2* suggest total cost is concave in *fteadmin*; total cost per student increases at a decreasing rate as the professional administrator per 100 student ratio increases. The implied peak value is 16 professional administrators per 100[27]; that value is well within the data experience, as the maximum value is 38 per 100. This result is also robust to specification and additional data. The elasticities of total cost at the quartiles of *fteadmin* are 0.097, 0.117, and 0.125, respectively.[28]

As anticipated by Bowen's revenue theory of cost, total cost is an increasing function of total operating revenue from the previous year. The coefficient for investment income is positive and significant at the 10% level. Since institutions use weighted average payout ratios from endowments, this result is not surprising.

7. Cost Analysis

Our primary objective is to deconstruct changes in total cost per student into Baumol and Bowen effects for the period from 1987 to 2008 and for 2008 to 2010. This is equivalent to "forecasting" within the sample experience. We use the total cost model, along with its partial differentials, to deconstruct the

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[26] The 95% interval estimates are [−0.113, −0.030], [−0.144, −0.039] and [−0.176, −0.047], respectively

[27] 95% interval estimate [11.81, 20.58]

[28] 95% interval estimates are [0.037, 0.156], [0.040, 0.193] and [0.028, 0.221].

different types of cost drivers. Among the 133 institutions in the cost analysis sample, total cost per student increased by $13,181 from 1987 to 2008 and by $546 from 2008 to 2010.

The cost deconstruction for different effects is then the partial differential for each of the 133 institutions using the model's estimated coefficients, the change in independent variables, and the predicted cost for 1987 and 2008. A weighted average value for the partial differential estimates is created using 1987 enrollment as the weights. The same procedure is used to deconstruct the cost changes between 2008 and 2010 using 2008 enrollment as the weights. Hence, the estimated cost effects are "forecasts" within each sample experience, since all changes in the independent variables are known and drawn from the sample. The results for the "loose" constraint and "tight" periods are contained in tables 3A and 3B, respectively.

The Partial Differentials: Econometric Methods

The log-linear specification implies the expectation

$$E\left(tc_{it}\right) = \exp\left(\beta' x_{it} + \alpha_i\right) E\left[\exp\left(u_{it}\right)\right] = \exp\left(\beta' x_{it}\right)\exp\left(\alpha_i\right) E\left[\exp\left(u_{it}\right)\right] \tag{2}$$

The predicted value should incorporate an estimate of $E\left[\exp\left(u_{it}\right)\right]$. We use the sample average of the fixed effects residuals $N^{-1}\sum_i \sum_t \exp\left(\hat{u}_{it}\right)$[29], where N = 891 is the total number of estimation sample observations. Other variants tried included the usual correction factor for the log-normal model $\exp\left(0.5\sigma^2\right)$, and also a group mean $\bar{\hat{u}}_{i\bullet} = T_i^{-1}\sum_t \exp\left(\hat{u}_{it}\right)$. Each of these corrections is very small and there were no meaningful differences among them in our calculations. Thus the predicted tc_{it} is

$$tc_{it} = \exp\left(\hat{\beta}' x_{it}\right)\exp\left(\hat{\alpha}_i\right)\left\{N^{-1}\sum_i \sum_t \exp\left(\hat{u}_{it}\right)\right\} \tag{3}$$

[29] Cameron and Trivedi (2010, 108) .

The total differential of $E\left(tc_{it}\right)$ is

$$dE\left(tc_{it}\right)=\exp\left(\beta' x_{it}\right)\exp\left(\alpha_i\right)E\left[\exp\left(u_{it}\right)\right]\left(\beta' dx_{it}\right) \tag{4}$$

We wish to compare outcomes in 1987 to those in 2008, and outcomes in 2008 to those in 2010. For each university *i*, we calculate

$$d(tc_i)=w_i\exp\left(\beta' x_{i,base}\right)\exp\left(\alpha_i\right)E\left[\exp\left(u_{it}\right)\right]\left(\beta' dx_i\right) \tag{5}$$

where $x_{i,base}$ are regressor values in the base year 1987 or 2008, and $dx_i = x_{i,2010}-x_{i,2008}$ or $dx_i = x_{i,2008}-x_{i,1987}$.[30] The differential is weighted by base year FTE student enrollment. Define

$$w_i = ftestu_{i,base}\Big/\left(\sum\nolimits_{i=1}^{n} ftestu_{i,base}\right) \tag{6}$$

Then

$$\begin{aligned} d(tc) &= \sum\nolimits_{i=1}^{n} w_i\exp\left(\beta' x_{i,base}\right)\exp\left(\alpha_i\right)E\left[\exp\left(u_{it}\right)\right]\left(\beta' dx_i\right) \\ &= \sum\nolimits_{i=1}^{n} c_i\exp\left(\beta' x_{i,base}\right)\left(\beta' dx_i\right) \end{aligned} \tag{7}$$

where $c_i = w_i\exp\left(\alpha_i\right)E\left[\exp\left(u_{it}\right)\right]$. The estimator of *d*(*tc*) is

$$d(tc)=\sum\nolimits_{i=1}^{n}\hat{c}_i\exp\left(\hat{\beta}' x_{i,base}\right)\left(\hat{\beta}' dx_i\right) \tag{8}$$

where $\hat{c}_i = w_i\exp\left(\hat{\alpha}_i\right)\left\{N^{-1}\sum_i\sum_t\exp\left(\hat{u}_{it}\right)\right\}$. Since $d(tc)=g\left(\hat{\beta}\right)$ is a nonlinear function of the estimator $\hat{\beta}$ inference uses the delta method[31]. The asymptotic distribution of the estimator in (7) is

[30] While our panel is unbalanced we have 133 matching observations for 1987, 2008 and 2010. We use these observations to compute the comparison values.

[31] William Greene (2012, Theorem D.22, 1086).

$$g\left(\hat{\beta}\right) \overset{a}{\sim} N\left[g\left(\beta\right), JVJ'\right] \tag{9}$$

where $J = \partial g\left(\beta\right)/\partial\beta'$, so that the estimator of the asymptotic variance of $d(tc)$ is $\hat{V}_{d(tc)} = \hat{J}\hat{V}\hat{J}'$, with $\hat{J} = \partial g\left(\beta\right)/\partial\beta'\big|_{\beta=\hat{\beta}}$ and $\hat{V}$ is a robust cluster corrected covariance matrix of $\hat{\beta}$.[32]

Given the form of the differential in (8) the Jacobian is

$$\begin{aligned} J &= \sum_{i=1}^{n} c_i \left[\exp\left(\beta' x_{i,base}\right)\left(\beta' dx_i\right) x'_{i,base} + \exp\left(\beta' x_{i,base}\right) dx'_i\right] \\ &= \sum_{i=1}^{n} c_i \exp\left(\beta' x_{i,base}\right)\left[\left(\beta' dx_i\right) x'_{i,base} + dx'_i\right] \end{aligned} \tag{10}$$

Deconstructions: Econometric Methods

Rather than the total differential we consider partial differentials using subsets of the regressor differential dx_i by setting some of its elements to zero. Specifically, the partial differential for the following incremental effects would involve subsets of the independent variables as follows:

1. Program Scale Changes: *ftestu*, *ftgrad*, *ptstu*, *ta*
2. Cost Savings: *cf*, *ptf*, *ftenpro*, *ptnpro*
3. Baumol Benefits: decomposed *benstaff*. The change in Baumol benefits is 51% of the actual change in *benstaff*.
4. Baumol Salaries: decomposed *staffsal*. The change in Baumol salaries is 52% of the actual change in *staffsal*.
5. Bowen Productivity: *ftef*, *fteadmin*, *fteadmin2*, *ptadmin*, *staffsize*
6. Bowen Salaries: decomposed *staffsal*. The change in Bowen salaries is 48% of the actual change in *staffsal*.

---

[32] Coefficient estimation was carried out using Stata 12.1. Subsequent calculations were carried out in SAS 9.3/IML.

7. Bowen Benefits: decomposed *benstaff*. The change in Bowen benefits is 49% of the actual change in *benstaff*.

8. Bowen Governance: *ttad*, *ttad2*.

9. Bowen Revenue: *rev*, *invest*, *donor*, *hosp*, *other*.

The differential estimates are computed for subsets of variables reflecting Program Scale changes (*ps*), Cost Savings (*cs*), Benefits (*ben*), Salaries (*sal*), Productivity (*prod*), Revenue (*rev*) and Governance (*gov*). To compare the theories of Baumol (*bau*) and Bowen (*bow*) we compute differential estimates for each. The Baumol components are salary and benefits, so

$$\begin{aligned} d(tc)_{tot}^{bau} &= d(tc)_{sal}^{bau} + d(tc)_{ben}^{bau} \\ &= \sum_{i=1}^{n} c_i \exp\left(\beta' x_{i,base}\right)\left[\beta'\left(dx_{i,sal}^{bau} + dx_{i,ben}^{bau}\right)\right] \\ &= \sum_{i=1}^{n} c_i \exp\left(\beta' x_{i,base}\right)\left(\beta' dx_{i,tot}^{bau}\right) \end{aligned} \tag{11}$$

The Bowen components of cost are productivity[33], salary, benefits, revenue and governance, so

$$\begin{aligned} d(tc)_{tot}^{bow} &= d(tc)_{prod}^{bow} + d(tc)_{sal}^{bow} + d(tc)_{ben}^{bow} + d(tc)_{rev}^{bow} + d(tc)_{gov}^{bow} \\ &= \sum_{i=1}^{n} c_i \exp\left(\beta' x_{i,base}\right)\left(\beta' dx_{i}^{bow}\right) \end{aligned} \tag{12}$$

where

$$dx_i^{bow} = dx_{i,prod}^{bow} + dx_{i,sal}^{bow} + dx_{i,ben}^{bow} + dx_{i,rev}^{bow} + dx_{i,gov}^{bow} \tag{13}$$

We would like to test the null and alternative hypotheses

[33] For the tight revenue period from 2008 to 2010, the institutions shifted from selective cost cutting to across the board cost cutting, they were no longer lowering administrative productivity as they did from 1987 to 2008. Bowen says rents are taken as lower productivity under loose revenue constraints and reversed during tight revenue constraints. What was Bowen lost "productivity" becomes improved productivity after 2008. Hence, the absolute value of the “productivity” effect is still a Bowen effect after 2008. This is accomplished by changing the sign of the Bowen productivity term in (13) for the 2008-2010 period.

$$
\begin{aligned}
H_0 &: d(tc)^{bow}_{tot} - h \cdot d(tc)^{bau}_{tot} = h(\beta) \le 0 \\
H_1 &: d(tc)^{bow}_{tot} - h \cdot d(tc)^{bau}_{tot} = h(\beta) > 0
\end{aligned} \tag{14}
$$

The test statistic is

$$
t = \hat{h}(\beta) \big/ se\left[\hat{h}(\beta)\right] \tag{15}
$$

The numerator is

$$
\begin{aligned}
\hat{h}(\beta) &= \sum_{i=1}^{n} c_i \ \exp\left(\hat{\beta}' x_{i,base}\right)\left(\hat{\beta}' dx_i^{bow}\right) - h \cdot \left[\sum_{i=1}^{n} c_i \ \exp\left(\hat{\beta}' x_{i,base}\right)\left(\hat{\beta}' dx_i^{bau}\right)\right] \\
&= \sum_{i=1}^{n} c_i \ \exp\left(\hat{\beta}' x_{i,base}\right)\left[\hat{\beta}'\left(dx_i^{bow} - h \cdot dx_i^{bau}\right)\right] \\
&= \sum_{i=1}^{n} c_i \ \exp\left(\hat{\beta}' x_{i,base}\right)\hat{\beta}' dx_i^{h}
\end{aligned} \tag{16}
$$

where $dx_i^h = dx_i^{bow} - h \cdot dx_i^{bau}$. The denominator of the *t*-statistic uses a variance calculation based on the delta method. Note that the form of the differential in (8) and (16) is the same, and thus the Jacobian matrix (10) is of the same form in both cases.

Discussion of Deconstructions

Salaries and Benefits. If staffing patterns do not change, one can interpret *staffsal* and *benstaff* as the average wage and benefit paid; but this is not the case, we know staffing patterns changed significantly. Therefore, we separate the changes in *staffsal* and *benstaff* due to staffing patterns from the total change in the two variables and assign the changes driven by staffing patterns to Bowen effects and the residual to Baumol effects. The cost disease holds that productivity is constant and that salaries are driven by external labor market conditions. Alternatively, declines in staff productivity are consistent with agency problems and Bowen's rule.

We measure the impact of changing staffing patterns on both *staffsal* and *benstaff* through correlation analyses between *staffsal/benstaff* and all of the staffing variables. The correlation analyses reveal that 48 percent of the variation in *staffsal* is accounted for by variation in the staffing variables and 49 percent of the variation in *benstaff* is accounted for by variation in the staffing variables. Hence, we assume the change in Baumol salaries equals 52 percent of the observed change in salaries and 51 percent of the observed change in *benstaff*.

Scale and Program Effects. Part of the total change is explained by changes in enrollment scale, program mix between graduate and undergraduate programs, and full-time/part-time attendance. Hence, changes in *ftestu*, *ftgrad*, *ptstu*, and *ta* represent the scale and program effects. The partial differential estimate for change in total cost per student is −$29 for the loose constraint period and $95 for the tight constraint period. If nothing else changed, real total cost per student would have gone down by $29 from 1987 to 2008 and up by $95 from 2008 to 2010. Since the sign of *ftestu* is negative and significant at the 0.10 level, increased undergraduate enrollment appears to have some scale effects on average total cost. Similarly, the positive and significant effect of part-time students on cost would also tend to lower cost as part-time enrollment declined throughout the period. The coefficients for *ftgrad* and *ta* are positive, suggesting the higher costs associated with growing graduate programs were offset by part-time student and scale effects from undergraduate enrollment.

Cost Saving. The public research universities reduced costs by reducing the non-professional staff/student ratio and using contract and part-time faculty more intensively. The partial differential estimates using *ftenpro*, *ptnpro*, *cf*, and *ptf*, suggest total cost declined by $4,080 per student. Had these cost savings been passed on to students and taxpayers, total cost per student would be lower by that amount during the loose constraint period. During the tight constraint period, the forgoing measures reduced cost by $757 per student. More significantly, the cost saving achieved by reversing reductions in productivity (lowering *ftef*, *fteadmin*, *ptadmin*, *ptnpro*, and *staffsize*) was $1,094 per student from 2008 to 2010.

During the loose constraint period, universities adopted selective productivity programs that excluded administrators and during the tight constraint period, universities adopted across the board productivity programs; this is the most dramatic change in behavior between the loose and tight regimes. Hence, universities can improve staff productivity.

Since total cost increased, it is clear the cost savings were spent on other activities. Therefore, the expected change in cost is equal to the actual change plus the cost that was saved. This is the amount that must be accounted for by Baumol and Bowen effects. The model estimates for the total change in cost per student are $17,291 from 1987 to 2008 and $2,301 from 2008 to 2010.

Baumol Effects. The classic Baumol effect is higher real wages and benefits with constant productivity. Implicit in this argument is that real wages and benefits are market driven and have no administrative content (no agency effects); further, the pure Baumol effect argues rising service costs are imposed on the service industries by general market effects that are external to the service industries per se.

As discussed above, Baumol salaries are 52 percent of the total change in *staffsal* and 51 percent of the total change in *benstaff*. During the loose constraint period, the partial differential Baumol salary estimate is $2,720. This represents 16 percent of the change in total cost per student. The Baumol benefits estimate is $59. The Baumol salary and benefits estimates for the tight revenue constraint period from 2008 to 2010 are $607 and $17, respectively.

Bowen Effects. In the presence of unresolved agency problems, one cannot assume that productivity will be maintained and that salaries will not have an administrative component. Contrary to Baumol's cost disease, the data reveal that faculty and staff productivity did not remain constant from

1987 to 2008, or from 2008 to 2010; nor did administrative staff productivity improve as we would expect from what was happening in the rest of the economy during that period (Jorgenson, et. al, 2008) (Gera and Gu, 2004). On the other hand, these staff changes are consistent with Bowen's rule.

The partial differential estimates for the Bowen adverse productivity effect are measured by changes in *ftef*, *fteadmin*, *ptadmin*, and *staffsize*. The estimate for total cost during the loose revenue constraint period is $3,593. This represents 21 percent of the increase in total cost for that period. The shift to improving productivity during the tight constraint period was discussed in the cost saving section. The partial differential estimate for Bowen salary effects is $2,510. This is 15 percent of the total for the loose revenue constraint period. The adverse effect of changes in faculty governance is measured by *ttad* and the partial differential estimate for total cost is $955. This is 6 percent of the total increase in cost during the loose revenue constraint period.

The combined effect of the revenue variables during the loose revenue constraint is $2,355 per student, which is 14 percent of the total change. During the tight revenue constraint, the revenue effect is $717, which is 29 percent of the change in cost per student.

In Table 1, the academic share of total cost increased from 48 percent in 2008 to 55 percent in 2010, a substantial increase for a two year period. This shift in the share suggests $2,744 per student was moved out of administrative costs and into academic costs. Since academic staffing reductions decreased cost by $808 per student, the total swing in academic cost per student was $3,552. If we assume all the cost reductions associated with *fteadmin*, *ftenpro*, *ptadmin*, *ptnpro*, and *staffsize* are part of the shift from administrative costs to academic costs, we account for $1,042 of the $3,552 shift; the rest remains unexplained.

Overview of Cost Analysis. If the 133 universities in the cost deconstruction sample kept the 1987 staffing patterns unchanged during the loose revenue period, real cost per student would increase by only $5,317 per student as opposed to the $13,181 change recorded; that is, the recorded change in cost per student would be only 40 percent of the actual change and that change would be due exclusively to salary/benefits and program changes. The total cost saving in 2008 for the 133 institutions in the cost deconstruction sample would be approximately $22 billion per year.

During the loose revenue constraint period, Baumol effects account for 16 percent of the increase in cost, while Bowen effects accounted for 55 percent. The Bowen effect to Baumol effect ratio in dollar terms is $3.4 to $1. In total, Baumol and Bowen effects account for 71 percent of the total change. Using a one-tail t-test, we conclude, at the 0.01 level of significance, that the Bowen total cost effect is more than twice the Baumol effect for both constraint periods.

The most favorable case to be made for Baumol effects relative to Bowen effects would be to assume that all changes in salaries and benefits are Baumol effects. In this case, for every $1 of increased cost explained by Baumol effects there would be $1.3 in Bowen effects. Even under this extreme case (all of the increase in FTE staff salaries and the increase in benefits are market driven), both Baumol and Bowen effects cause costs to increase and Bowen effects exceed Baumol effects. Another unfavorable case for the significance of Bowen effects is contained in Table 3A and Table 3B; we assume all Baumol effects are at the upper bound, while all Bowen effects are at the lower bound for their respective 95 percent confidence intervals. Under this assumption, the estimate is $2.2 to $1. A realistic allocation of salaries and benefits suggests Bowen effects exceed Baumol effects by at least 2 to 1.

The deconstruction of cost changes during two years of tight revenue 2008 to 2010 reveals that the Bowen/Baumol ratio is about $3.8 to $1. The most significant changes between loose constraints to tight constraints are the productivity effect shifts from reductions in productivity to increases in productivity and to a dramatic increase in the academic share of total cost. The data also reveal the institutions intensified their traditional cost saving behavior after 2008. From this information and the historical record for decreases in cost during the Great Depression and during the 1970's it appears tight revenue lowers agency effects, while loose revenue tends to induce agency effects. This is very intuitive.

8. Conclusions

We estimate a total cost function for public research universities. Some higher education cost studies assume costs are minimized. These studies are consistent with the argument that higher costs are imposed on colleges and universities by the macro-economy (since they are minimizing cost) and not due to internal decisions taken by these universities. If costs are minimized, duality insures that cost functions can be estimated with input prices and output. Bowen's rule implies costs are not minimized due to unresolved agency problems and the peculiarities of experience goods. Therefore, staff/student ratios are essential control variables for unraveling changes in costs due to decisions taken inside higher education. Our results demonstrate that staff/student ratios are collectively and individually significant; Bowen's rule has a significant impact on cost.

There are three shared governance hypotheses unique to higher education. A popular hypothesis is intransigent tenure-track faculty prevent costs from being minimized by cost conscious administrators. If this is the case, the shared governance metric (the ratio of tenure-track faculty to full-time professional administrators) should be positively correlated with cost. However, the ratio is significant and negatively correlated, which suggests the cost problem is primarily due to overspending by administrators. The data further suggests cost is convex in the tenure-track/administrator ratio. Convexity of cost is consistent with the hypothesis that shared governance is a constraint on agency abuse by any agent group in higher education. The pattern of these results mean the higher education cost problem will be made worse if tenure-track faculty lose all influence on resource allocation.

We believe the current optimal staffing ratio is a product of existing governance contracts and we believe those contracts are weak as it relates to the faculty's role in resource allocation decisions. If the faculty's role in resource decisions was codified in campus governance (the role is strengthened by contract), stronger agency constraints would lead to lower cost and a lower optimal tenure-track to administrator ratio.

The partial differential method is used to deconstruct the cost changes observed from 1987 to 2008 and from 2008 to 2010 into their component parts. The primary cost categories are scale/program changes, cost saving changes, Baumol effects, and Bowen effects. We find that both Baumol and Bowen effects drive costs higher; however, Bowen effects tend to be over twice as large as Baumol effects during both loose and tight revenue constraints. Most of the increases in cost during this period came from decisions taken inside higher education.

The significance of staffing ratios in the cost equations, the shared governance result, the deconstruction of historical costs, and the revenue effects are all consistent with Bowen's rule. We take these findings as evidence that Bowen's revenue theory is valid.

However, our model does not account for all possible influences on cost. First, we have not accounted for all possible Baumol or Bowen effects in the model. The essence of the Baumol hypothesis is significant costs are imposed on higher education from the general economy within which it is embedded, an undoubtedly true statement. Likely sources of additional Baumol effects are scientific equipment costs and energy cost for which we have no direct controls. Similarly, we have not accounted for all possible Bowen effects such as those due to reputation competition and the arms race to spend more on physical plant, research, and public service. Finally, we have not controlled for new government mandates. Our research is the first step in the process of deconstructing real cost changes into their component parts.

Table 1
Public Research Universities:
Weighted Average Values and Annual Growth Rates

Year	Label	1987	2008	2010	87 to 08	08 to 10
Academic Cost	(*ac*)	$13,901	$19,011	$22,136	1.8	8.2
Overhead Cost	(*oh*)	$14,677	$22,436	$19,717	2.5	−6.1
Total Cost	(*tc*)	$28,578	$41,447	$41,853	2.1	0.5
Academic Share		49.3	47.9	55.1	−0.1	7.5
Enrollment:						
FTE Students*	(*ftestu*)	16640	21396	22541	1.4	2.7
FT Undergrad	(*fteug*)	15354	19756	20407	1.4	1.6
FT Grad	(*ftegrad*)	3248	4540	4829	1.9	3.2
PT Students	(*ptstu*)	2605	2216	2211	−0.7	−0.1
Teaching:						
Contract Fac	(*cf*)	1.9	2.4	2.5	1.0	1.7
PT Faculty	(*ptf*)	0.4	0.7	0.4	2.7	−18.1
Teach Assist	(*ta*)	1.4	2.2	2.7	2.7	11.3
Tenure-track	(*tt*)	4.3	4.5	4.4	0.2	−1.5
TT fac/Admin	(*ttad*)	1.0	0.6	0.6	−1.9	−0.2
FTE Fac	(*ftef*)	6.7	7.5	7.2	0.6	−1.9
Administration:						
FTE Admin	(*fteadmin*)	6.6	9.5	9.3	2.1	−1.2
FTE Ex/Mgr	(*fteex*)	1.3	1.4	1.3	0.3	−2.9
FTE Pro	(*ftepro*)	5.2	8.1	7.9	2.6	−0.9
FTE Non-Pro	(*ftenpro*)	11.2	7.9	7.3	−1.4	−4.0
Staff Size	(*staffsize*)	14.4	15.5	15.3	0.4	−0.6
Salaries/Benefits:						
Full Prof		$94,247	$111,304	$112,380	0.9	0.5
Assistant Prof		$59,205	$68,142	$68,959	0.7	0.6
Staff Salary	(*staffsal*)	$53,807	$76,020	$79,708	2.0	2.4
Benefits	(*benstaff*)	$12,076	$23,616	$25,890	4.6	4.8
Revenue:						
Total Op Rev	(*rev*)	$27,338	$40,905	$42,868	2.4	2.4
Core	(*core*)	$18,115	$20,956	$21,132	0.7	0.4
Donor	(*donor*)	$1,462	$3,896	$1,225	7.9	−34.3
Hosp	(*hosp*)	$2,521	$4,419	$5,475	3.6	11.9
Other	(*other*)	$5,240	$11,633	$15,036	5.8	14.6
Invest Inc	(*invest*)	$245	$2,641	−$1,986	46.7	−87.6

* Unweighted mean

Table 2 Estimates for the Total Cost Equation

	(1) OLS	(2) RE	(3) RE_ROB	(4) FE	(5) FE_ROB
cf	-0.0271***	-0.0364***	-0.0364***	-0.0412***	-0.0412***
	(0.0078)	(0.0057)	(0.0079)	(0.0058)	(0.0087)
ptf	-0.0131	-0.0206**	-0.0206**	-0.0245***	-0.0245**
	(0.0092)	(0.0080)	(0.0087)	(0.0082)	(0.0095)
ta	0.0039	0.0047	0.0047	0.0040	0.0040
	(0.0036)	(0.0030)	(0.0029)	(0.0031)	(0.0029)
ftef	0.0544***	0.0617***	0.0617***	0.0663***	0.0663***
	(0.0069)	(0.0051)	(0.0084)	(0.0052)	(0.0103)
ftestu	0.0004	-0.0015	-0.0015	-0.0046**	-0.0046
	(0.0016)	(0.0013)	(0.0018)	(0.0019)	(0.0028)
ftgrad	0.0032	0.0118**	0.0118*	0.0192**	0.0192**
	(0.0060)	(0.0051)	(0.0061)	(0.0075)	(0.0090)
ptstu	0.0004	0.0077*	0.0077	0.0178***	0.0178***
	(0.0061)	(0.0040)	(0.0063)	(0.0058)	(0.0066)
ttad	-0.1252**	-0.1581***	-0.1581***	-0.1690***	-0.1690***
	(0.0500)	(0.0380)	(0.0482)	(0.0394)	(0.0498)
ttad2	0.0260***	0.0272***	0.0272***	0.0275***	0.0275***
	(0.0099)	(0.0086)	(0.0089)	(0.0088)	(0.0089)
staffsal	0.0060***	0.0067***	0.0067***	0.0068***	0.0068***
	(0.0008)	(0.0004)	(0.0008)	(0.0005)	(0.0008)
benstaff	0.0024*	0.0010	0.0010	0.0003	0.0003
	(0.0012)	(0.0008)	(0.0013)	(0.0008)	(0.0015)
fteadmin	0.0564***	0.0431***	0.0431***	0.0311***	0.0311***
	(0.0078)	(0.0055)	(0.0081)	(0.0059)	(0.0089)
fteadmin2	-0.0017***	-0.0013***	-0.0013***	-0.0010***	-0.0010***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
ftenpro	0.0262***	0.0283***	0.0283***	0.0277***	0.0277***
	(0.0030)	(0.0018)	(0.0028)	(0.0022)	(0.0030)
ptadmin	0.0209	0.0234*	0.0234	0.0268**	0.0268
	(0.0150)	(0.0121)	(0.0160)	(0.0136)	(0.0185)
ptnpro	-0.0231**	-0.0107	-0.0107	-0.0005	-0.0005
	(0.0096)	(0.0069)	(0.0079)	(0.0073)	(0.0098)
staffsize	0.0020***	0.0016***	0.0016***	0.0012***	0.0012***
	(0.0004)	(0.0004)	(0.0003)	(0.0004)	(0.0004)
rev	0.0093***	0.0080***	0.0080***	0.0060***	0.0060**
	(0.0024)	(0.0013)	(0.0024)	(0.0015)	(0.0026)
donor	0.0027	-0.0038	-0.0038	-0.0081**	-0.0081
	(0.0056)	(0.0030)	(0.0053)	(0.0032)	(0.0052)
hosp	-0.0034	-0.0019	-0.0019	0.0002	0.0002
	(0.0020)	(0.0014)	(0.0019)	(0.0017)	(0.0022)
other	-0.0018	-0.0022	-0.0022	-0.0019	-0.0019
	(0.0024)	(0.0016)	(0.0024)	(0.0018)	(0.0025)
invest	-0.0016	0.0012	0.0012	0.0033**	0.0033*
	(0.0023)	(0.0016)	(0.0019)	(0.0016)	(0.0017)

Table 2 (continued): Estimates for the Total Cost Equation

	(1) OLS	(2) RE	(3) RE_ROB	(4) FE	(5) FE_ROB
city	-0.0467***	-0.0605***	-0.0605***		
	(0.0158)	(0.0151)	(0.0177)		
rural	-0.0093	-0.0122	-0.0122		
	(0.0162)	(0.0214)	(0.0188)		
carnegie	0.0130	0.0276	0.0276		
	(0.0212)	(0.0177)	(0.0247)		
fwest	0.0171	0.0301	0.0301		
	(0.0214)	(0.0204)	(0.0228)		
glakes	0.0524***	0.0579***	0.0579***		
	(0.0158)	(0.0173)	(0.0177)		
neweng	0.0795***	0.0943***	0.0943***		
	(0.0203)	(0.0196)	(0.0229)		
stem	0.0109	0.0181	0.0181		
	(0.0184)	(0.0192)	(0.0220)		
medical	0.0270	0.0407**	0.0407**		
	(0.0170)	(0.0174)	(0.0200)		
prof	-0.0319	-0.0369*	-0.0369		
	(0.0224)	(0.0209)	(0.0252)		
d1989	-0.0212*	-0.0201*	-0.0201*	-0.0224*	-0.0224**
	(0.0115)	(0.0121)	(0.0106)	(0.0119)	(0.0095)
d1991	-0.0634***	-0.0573***	-0.0573***	-0.0569***	-0.0569***
	(0.0170)	(0.0124)	(0.0173)	(0.0124)	(0.0179)
d1999	0.0257	0.0409***	0.0409**	0.0649***	0.0649***
	(0.0168)	(0.0136)	(0.0167)	(0.0145)	(0.0187)
d2005	0.0083	0.0380**	0.0380*	0.0778***	0.0778***
	(0.0226)	(0.0172)	(0.0222)	(0.0192)	(0.0259)
d2008	0.0124	0.0553***	0.0553**	0.1059***	0.1059***
	(0.0241)	(0.0180)	(0.0243)	(0.0205)	(0.0285)
d2010	0.0164	0.0579***	0.0579**	0.1093***	0.1093***
	(0.0270)	(0.0189)	(0.0268)	(0.0220)	(0.0316)
constant	8.7325***	8.7795***	8.7795***	8.9042***	8.9042***
	(0.0826)	(0.0507)	(0.0916)	(0.0632)	(0.1134)

Standard errors in parentheses

* p<0.10, ** p<0.05, *** p<0.01

Table 2 (continued): Estimates for the Total Cost Equation

Variable	**Brief Description**
tc	real total cost per student
cf	number of contract faculty per 100 students
ptf	number of part-time faculty per 100 students
ta	number of teaching assistants per 100 students
ftef	number of FTE faculty per 100 students
ftestu	FTE student enrollment
ftgrad	number of full-time graduate students including professional students
ptstu	number of part-time students
ttad	ratio of tenure-track faculty to full-time nonacademic professional employees
ttad2	ttad squared
staffsal	total salaries and wages paid per FTE staff employed
benstaff	total employee benefits paid per full-time staff member
fteadmin	number of FTE executive and professional employees per 100 students
fteadmin2	fteadmin squared
ftenpro	number of FTE non-professional employees per 100 students
ptadmin	number of part-time administrators per 100 students
ptnpro	number of part-time nonprofessional staff per 100 students
staffsize	number of FTE administrators and staff per executive
rev	real operating revenue per student in prior year
donor	real donor revenues per student in prior year
hosp	real hospital revenue per student in prior year
other	real other revenue per student in prior year
invest	real investment income per student in prior year
city	=1 if institution located in large or midsize city
rural	=1 if institution located in fringe, distant, or remote rural areas
carnegie	=1 for Carnegie I research institutions
fwest	=1 if located in far west coast region
glakes	=1 if located in Great Lakes region
neweng	=1 if located in New England region
stem	=1 if institution emphasizes STEM disciplines
medical	=1 for institutions with medical or veterinary schools
prof	=1 if institution emphasizes professional schools
d1989	=1 if year is 1989
d1991	=1 if year is 1991
d1999	=1 if year is 1999
d2005	=1 if year is 2005
d2008	=1 if year is 2008
d2010	=1 if year is 2010

Table 3A
Total Cost
Loose Revenue Constraint: 1987 to 2008

		95% Bounds	
		Lower	Upper
Actual Change	$13,181		
Cost Saving	−$4,080	−$4,964	−$3,196
Program Changes	−$29	−$711	$652
Change	$17,291		
Baumol Effects:			
Salaries	$2,720	$2,057	$3,382
Benefits	$59	−$477	$596
Subtotal	$2,779	$1,934	$3,623
Bowen Effects:			
Productivity	$3,593	$2,437	$4,749
Salaries	$2,510	$1,899	$3,122
Benefits	$57	−$458	$572
Governance	$955	$410	$1,501
Revenue	$2,355	$720	$3,990
Subtotal	$9,471	$8,013	$10,929
Explained	$12,250	$10,270	$14,230
Bowen/Baumol Ratio	3.4		

Table 3B
Total Cost
Tight Revenue Constraint: 2008 to 2010

		95% Bounds	
		Lower	Upper
Actual Change	$546		
Cost Saving	−$757	−$1,161	−$352
Program Changes	$95	−$126	$316
Sub Total	$1,207		
Baumol Effects:			
Salaries	$607	$454	$761
Benefits	$17	−$134	$168
Subtotal	$624	$402	$847
Bowen Effects:			
Positive Effects			
Salaries	$561	$419	$703
Benefits	$16	−$129	$161
Governance	$4	$0	$8
Revenue	$717	−$92	$1,527
Subtotal	$1,298	$468	$2,129
Negative Effects			
Productivity	−$1,094	−$1,390	−$797
Explained	$1,923	$1,015	$2,830
Absolute Dollars	$2,301		
Baumol/Bowen Ratio	3.8		

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