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# Efficiency-Based Funding for Public Four-Year Colleges and Universities


## Abstract

We propose an efficiency-based mechanism for state funding of public institutions of higher education, based on the methodology of Data Envelopment Analysis. We describe the philosophy and the mathematics that underlie the approach and apply the proposed model to actual data from 362 public four-year colleges and universities in the U.S. The model provides incentives to institution administrators to eliminate wasteful spending and increase positive outcomes while maintaining the quality of the education the institutions provide and the research that their faculty members produce. The institutions in our study spent a total of \$96.74 billion and they would receive a total reimbursement of \$88.02 billion. Thus, the efficiency-based funding formula would reduce state government expenditures on these institutions by \$8.72 billion, or approximately 9.0%. The political viability of an efficiency-based funding model like the one described here is demonstrated by the fact that North Carolina has successfully used a similar approach to fund its pupil transportation operations since 1994. The model will be of interest to state legislators, state education officials, and others who are concerned with funding formulas for institutions of higher education.

## Introduction

A funding mechanism does more than simply determine how a government agency will fund service providers. It also creates behavioral incentives for the providers that can significantly influence the nature, effectiveness, and efficiency of their operations. In simplest terms, the agency should expect providers to produce more of those services that are rewarded most heavily and less of those that are rewarded less heavily or penalized (Liefner, 2003). Thus, funding mechanisms have the potential to significantly alter the very nature of the providers and the services that they offer.

For example, we should not be surprised to see that physicians and outpatient clinics perform many procedures and order many tests. The fee-for-service funding mechanism used by Medicare, Medicaid, and health insurance companies is structured such that these health care providers are reimbursed based on the number of procedures they perform and the number of tests that they order. By contrast, hospitals are reimbursed on a prospective payment system under which the amount of the reimbursement depends only on the patient's primary diagnosis and is independent of, with certain exceptions, the specific services provided to the inpatient, including how long the patient stays in the hospital. When prospective reimbursement replaced fee-for-service reimbursement in the mid 1980s, hospital length of stay dropped dramatically along with the number of services provided to inpatients. In addition, hospitals began to expand their outpatient services so that they could shift many procedures and tests from the inpatient setting to the outpatient setting where they could capitalize on the fee-for-service funding mechanism. The trend continues today.

Two popular approaches to state funding for higher education are activity-based formulas and outcome-based formulas. We describe these approaches briefly and provide examples of states that use each method. Our purpose in this paper is to present a new approach: efficiency-based funding. Activity-based approaches fund institution based on activity level while outcome-based approaches fund institutions based on achieved outcomes. The expectation is that activity-based methods will lead to more activities (i.e., enrollment) and outcome-based methods will result in greater desired outcomes (i.e., degrees awarded). Neither of these approaches however addresses resource consumption. An efficiency-based approach funds institutions based on their demonstrated efficiency, the maximization of outcomes with minimal inputs.

## State Higher Education Funding

States face severe budget constraints and as a result, higher education funding has suffered. Higher education faces funding competition from both K-12 needs as well as other state priorities. Since the traditional functions of state government have been defined as "educate, medicate and incarcerate," higher education faces funding competition from both medical care (i.e., Medicaid) and law enforcement (i.e., prisons). Medicaid expenditures alone (state and federal) have exploded from $145 million annually to $315 million between 1995 and 2005 (Iglehart, 2007).

State appropriations for education have increased in nominal terms, but have fallen short in real terms. As a consequence, the percentage of public higher education financed through state appropriations has decreased, with tuition, donations, and other sources funding a larger share of public higher education. This has led to the rise of so-called "quasi-private" or state-assisted, versus state-supported institutions. For example, the University of Wisconsin-Madison received 20% of its budget from state appropriations in 2004, versus 35% in 1988 (Weerts and Ronca, 2006) and only 25% of the University of Texas's 1998 funding came from state appropriations (Liefner, 2003). A result of the reduced state funding is a demand by public colleges and universities for reduced oversight and involvement by state officials in institutional affairs (Varghese, 2004).

The scarcity of state resources has also forced officials to demand greater accountability and efficiency from public colleges and universities in return for continued support. Balancing these factors has now forced state officials to develop new mechanisms for funding higher education. Traditional funding mechanisms have focused on inputs (i.e., number of students) or outputs (i.e., graduation rates), but not the efficient use of inputs to achieve those outputs.

## Incremental Budgeting, Activity-Based Funding and Outcome-Based Funding

Each state selects its own method for funding higher education and it is safe to say that no two states use exactly the same method (McKeown and Layzell, 1994). The most common approaches have been described as incremental budgeting, activity-based formula models and performance-based outcome models. The total budget allocation for public colleges and universities is often based on multiple methods. Funding for operating expenditures is often separate from funding for capital expenditures.

Incremental budgeting is the oldest approach. Incremental budgeting starts with the current year's budget and adjusts for anticipated activities next year, along with expected changes in revenues and expenditures. This method provides stability but does not recognize unique institutional characteristics. Additionally, it does not incorporate performance or efficiency in budget decisions (Layzell, 2007). Because of these limitations, incremental budgeting has fallen in popularity in recent decades.

Activity-based funding formula models for public higher education have been around for over fifty years, starting with Texas and California in the 1950's (McKeown and Layzell, 1994). These models attempt to estimate the average unit cost of each activity, such as enrolling a student in a course, and then estimating the institution's total cost by computing the total cost of each activity (cost per student enrolled times the number of students enrolled, for example) and then summing over all activities. Funding formulas were originally developed to identify a predictable and adequate resource base, with minimal political intervention (McKeown-Moak, 1999). McKeown (1996) has identified four trends in the recent use of activity-based funding formulas: increased detail, increased budget control and monitoring, increased use of non-formula components, and reduced significance of enrollment in the formulas.

Activity-based budgeting focuses on measures related to the three traditional missions of public colleges and universities: instruction, research, and public service. A common measure for instructional activity includes full-time equivalent enrollment, in total or separated into undergraduate and graduate enrollment. Common approaches for research funding include funding a percentage of grant matching and funding research based upon a percentage of the instructional budget. Public service funding usually entails a relatively nominal amount, often based on a formula similar to research funding (i.e., 5% of instructional funding) (McKeown and Layzell, 1994).

One example of an activity-based funding formula is that adopted by New Mexico in 2003. New Mexico's "Base Plus/Minus" model assigns each course taught by a institution to a cell in a 3x3 matrix (Pestalozzi M. T., 2008). The rows of the matrix are tiers based on the estimated average cost of providing instruction. The columns of the matrix are the levels of instruction: lower-division undergraduate, upper-division graduate, and graduate. The instructional funding for an institution is determined by multiplying the number of credit hours provided by the institution in each cell of the matrix times the estimated average cost of providing instruction in that cell, and summing across all cells. Various other costs are estimated and added, such as for student services and for physical plant operation and maintenance, and various revenue credits that the institution receives from other sources are subtracted. A series of adjustments then result in a recommended general fund appropriation.

As another example of an activity-based funding formula, Missouri instituted a new funding mechanism for FY2010 (Coordinating Board for Higher Education, 2008). The allocation strategy provides that university appropriations above an inflationary increase will be distributed according to the funding gap between the national average state support per full-time equivalent (FTE) student for public four-year institutions and state support per FTE student in Missouri. The funding gap is distributed on the basis of weighted full-time equivalent students. As in New Mexico, the weighting factors are based on academic program and student level, recognizing the varying costs associated with different programs and levels of instruction. Enrollment growth is also factored into the model.

A more recent approach, outcome-based or performance-based budgeting, focuses on identified institutional outcomes, such as a graduation rates, retention, or placement, and rewards the institution for each positive outcome achieved. Outcome-based funding has grown significantly in popularity since the mid-1980s (Alexander, 2000). According to Layzell (2007), the increased use of outcome measurements for budgeting is born out of a desire by both politicians and the electorate for greater accountability. For example, Ohio is developing a new outcome-based funding mechanism based on course completions (rather than enrollments), degree attainment, doctoral education funding, research funding, medical education funding, and mission-specific goals (IUB Subcommittee of the OBR Subsidy Funding Consultation, 2008). The funding mechanism includes a quality measure that rewards institutions for "at risk" students who complete degrees.

Consider the incentives created by each method. Incremental funding fits well when institutions are stable and changes from year to year are relatively small. By its nature, incremental funding mechanisms encourage stability but are less accommodating to larger initiatives. Thus, an institution that faces incremental budgeting is more likely to do more of the same activities. Conversely, it is less likely to be innovative, to remain current with new developments in teaching and research, and to look for ways to reduce costs.

We can expect that an institution faced with an activity-based funding mechanism will seek to increase those activities that provide payment in excess of actual marginal cost. For example, we should look for higher course enrollments and larger classes but not necessarily higher course completions or awarded degrees. This may lead a institution to admit students who are unprepared for higher education and who have little chance of earning a degree, thereby lowering overall educational quality and driving the more qualified students to seek higher education elsewhere. Moreover, since the institution will increase only those activities that provide payment in excess of actual marginal cost, the state will incur higher costs, some of which simply increase the institution's net revenue even though the educational experience may have deteriorated.

An institution faced with an outcome-based funding mechanism will seek to increase those outcomes with the greatest reward relative to the cost of earning that reward. For example, if the institution is rewarded for each undergraduate degree awarded, then we should look for increases in the number of undergraduate degrees awarded. However, institutions may be inclined to focus on measured outcome performance at the expense of educational quality. For example, tying state funding to retention rates may lead to grade inflation, or tying funding to graduation rates may lead to institutions recruiting fewer at-risk students (Stuart, 2010). If the reward for graduate degrees exceeds the cost of providing the necessary graduate education, then we should expect the institution to expand graduate offerings at the expense of undergraduate offerings. The core of outcome-based budgeting is the linkage between funding and institution performance. A drawback is that outcome-based budgeting does not provide stability and thus makes budget planning by institutions difficult.

Outcome-based budgeting has not received a great deal of support in the literature. Shin (2010) analyzed changes in institutional performance, measured by graduation rates and external research funding, following adoption of performance-based budgeting and found no significant increase. Conner and Rabovsky (2011) likewise found no significant relationship between performance-budgeting and student outcomes, using state *Measuring-Up* scores.

It is easy to see how the incentives created by the funding mechanism will create behavioral changes on the part of the institutions. While we can certainly hope that institution administrators will not deliberately undermine the value of the education their institutions provide, we must also remain cognizant of the fact that tight budgets will force administrators to find ways to remain solvent. Although some of the consequences may be desirable, such as greater emphasis on graduate study, some of the consequences will be undesirable, such as grade inflation.

Since every state needs a funding mechanism, the problem is to create one that provides incentives for desirable behaviors and disincentives for undesirable behaviors. Moreover, institutions need to attain desirable outcomes at the lowest cost. Incremental funding will support stability but is likely to hinder creative initiatives that require substantial up-front investment. Activity-based funding will allocate greater resources to institutions experiencing greater enrollment, while outcome-based funding will increase resource allocation to institutions with greater positive outcomes. However, a weakness of all three funding methods is the absence of efficiency in the calculation. That is the goal of efficiency-based funding.

## The Philosophy of Efficiency-Based Funding

The efficiency-based funding approach adopts the following philosophy. First, the state should fund each public higher education institution for the cost of running an efficient operation but it should not subsidize inefficient operation. Consequently, the funding approach must provide incentives to institutions to eliminate wasteful spending and to find creative ways to deliver education and produce research effectively and with minimal cost. The goal is the attainment of a minimal cost for a given level of output.

Second, institutional administrators are best qualified to determine how to improve their systems. They are the only people who are sufficiently familiar with the details, nuances, and intricacies that play important roles in delivering educational and research outputs in their location. Therefore, the funding approach should not impose constraints on how administrators achieve higher efficiency since institutional autonomy is a desirable attribute in any funding approach (Weerts and Ronca, 2006).

Third, the incentives induced by the funding system to improve efficiency should not encourage institutions to compromise the safety or quality of their operations. As important as efficiency is to the institutions and to the state, the funding system must not allow institutions to increase their appropriation by neglecting safety or noticeably reducing the quality of their educational and research outputs.

Like all funding approaches, the efficiency-based funding approach must be fair, clear, and easy to administer (Okunade, 2004). Fairness implies that the funding approach must explicitly incorporate all relevant conditions faced by the institutions. No higher education institution should benefit from relatively favorable operating conditions, nor should the funding approach penalize any institution that faces relatively unfavorable operating conditions. Clarity implies that the funding approach is sufficiently simple and well explained to permit both the state and the institution to understand its fundamental steps. This understanding must be sufficient to ensure that all parties can reasonably predict the consequences of relevant policy and operational changes. This is essential for budget planning purposes. We must interpret clarity relative to the complexity of the higher education operation, recognizing that such a complex operation is likely to require a complex reimbursement approach. Administrative ease implies that the state and the institution can implement the funding approach with reasonable effort using readily available data and widely available computer software.

## Evaluating Efficiency in Higher Education

Two approaches have been identified to examine institutional efficiency: stochastic frontier estimation and data envelopment analysis (DEA). Both methods have been used to assess efficiency in public higher education. Robst (2001) used stochastic frontier estimation to assess the role of state appropriation levels on higher education efficiency. He found that as higher education funding decreased, efficiency improved. However, to the extent the funding reductions were offset by tuition increases, efficiency actually worsened.

DEA is a popular tool for measuring efficiency in non-profit organizations, such as universities, since it easily handles multiple inputs and outputs (Kuah and Wong, 2011). DEA has been used recently for assessing efficiency in higher education. Abbott and Doucouliagos (2003) utilized DEA to assess the efficiency of Australian universities incorporated into the Unified National System. Their results indicated that the institutions were operating at fairly high levels of efficiency relative to one another. Johnes (2006) used DEA to measure efficiency among 100 higher education institutions in the United Kingdom and found results consistent with Abbot and Doucouliagos. Similar results were found examining institutions in Germany (Fandel, 2007) and Japan (Hashimoto and Cohn, 1997).

## How Efficiency-Based Funding Works

Our article expands the literature by utilizing DEA to not only assess higher education efficiency in the United States but also to incorporate that efficiency into higher education funding. We propose an input-oriented two-stage DEA model (Lewis and Sexton, 2003) for public institutions of higher education, as shown in Figure 1. In the first stage, the institution recruits students and hires faculty members. In the second stage, the institution educates students. To specify a two-stage DEA model, we need to identify the inputs, intermediate products, and outputs, as well as the stage at which each input enters and the stage from which each output exits. In addition, we need to specify the site characteristics (factors that influence resource consumption but are beyond the direct control of management).

* * * Figure 1 here * * *

For funding institutions of higher education, we propose two inputs, both of which enter Stage 1: (1) the institution's operating expenses, and (2) its capital expenditures. Operating expenses include salaries, utility costs, maintenance costs, and other general administrative expenses. We measure this input by the institution's annual operating budget. Capital expenditures include land, buildings, land improvement, equipment, infrastructure, arts and library collections, and other long-term revenue producing assets. We measure this input (exclusive of land) by the institution's annual depreciation expense, consistent with Johnes (2006).

We propose one intermediate product: enrollment. We measure enrollment as the institution's 12-month full-time equivalent enrollment, which includes students at all levels enrolled for credit, consistent with Flegg *et al*. (2004).

We propose six outputs: its research production, which exits from Stage 1, and its number of degrees granted at five levels (associates, baccalaureate, masters, doctoral, and first professional), which exit from Stage 2. We measure research production by the institution's total research expenditures (Cohn *et al*., 1989).

We include seven site characteristics for Stage 1. They are (1) the consumer price index (CPI-U) for the region in which the institution is located, (2) whether the institution is located in an urban setting (a binary indicator variable), (3) the Carnegie Classification Code (CCC) for the mission of the institution, as a site characteristic for Stage 2, (4 and 5) Scholastic Aptitude Test (SAT) scores in reading of admitted students at both the $25^{th}$ and $75^{th}$ percentiles, and (6 and 7) SAT scores in mathematics of admitted students at both the $25^{th}$ and $75^{th}$ percentiles.

The CPI-U is the Consumer Price Index for All Urban Customers and is published monthly by the U.S. Department of Labor, Bureau of Labor Statistics. The CPI-U represents about 87 percent of the total U.S. population. It is based on the expenditures of almost all residents of urban or metropolitan areas, including professionals, the self-employed, the poor, the unemployed, and retired people, as well as urban wage earners and clerical workers. The CPI-U index is published for the four census regions: Northeast, Midwest, South, and West. We include CPI-U as a site characteristic because institutions that operate in higher cost regions are likely to spend more on salaries and other costs.

We include the degree of urbanization of the institution's location because it allows us to refine further the cost differences among institutions within a region. For example, an institution located within a city in the Northeast would likely incur higher costs than one located in the Northeast but not within a city.

We include the Carnegie Classification Code to control for the institution's mission. There are 26 CCCs, which we collapsed into 6 categories (see Table 1) for analysis purposes:

1. Research (R)
2. Masters (M)
3. Baccalaureate (B)
4. Associate (A)
5. Special Focus (S)
6. Other (O)

Table 1 also includes the number and percentage of institutions in each category.

We include the SAT scores of admitted students because they serve as indicators of the overall level of preparation of admitted students for higher education (Koshal and Koshal, 1995). While an institution has some control, within the confines of its mission statement, over the SAT scores of admitted students, we include these variables as site characteristics because institutions that attract higher-achieving students are likely to have higher costs. This is because they may offer smaller (and therefore more) class sections, offer more scholarships, better classroom and living facilities, and more special programs such as honors programs. The use of test scores as a measure of student quality is also consistent with Johnes (2006) analysis of UK institutions.

The key to the DEA model is the identification, for each institution in the data set, of a *target institution*, which is a weighted average of all institutions in the data set. An input-oriented DEA model uses the optimization power of linear programming to identify, for each institution, how much weight to place on each institution in the data set to produce a target institution that reduces both operating expenses and capital expenditures as much as possible while maintaining the same (or higher) levels of degrees awarded and research production. The target institution does so while operating under the same or worse site characteristics.

Suppose, for example, that the linear program for Institution A identifies its target institution to be 60% of Institution B, 30% of Institution C, and 10% of Institution D. Suppose further that CPI-U and URBAN, the binary indicator for urban setting, are the only site characteristics. Then the operating expenses (in millions of dollars), capital expenditures (in millions of dollars), total degrees awarded, research expenditures (in millions of dollars), CPI-U, and value of URBAN of Institution A's target institution equal 60% of the value at Institution B plus 30% of the value at Institution C plus 10% of the value at Institution D. Table 2 shows hypothetical data for Institutions A through D and for Institution A's target.

* * * Table 2 here * * *

Thus, the operating expenses for Institution A's target is (0.6)($1,000) + (0.3)($100) + (0.1)($2,000) = $600 + $30 + $200 = $830 million. We perform the calculations for capital expenditures, total degrees awarded, research expenditures, CPI-U, and URBAN in the same manner. The important observation is that Institution A's target performs better than Institution A. The target spends $70 million less on operations, $10 million less on capital, awards an additional 330 degrees, and brings in $20 million more in research support while it operates in a region with the same CPI-U. Note that Institution A is an urban institution and that all of the institutions upon which it places weight are also urban institutions. The model ensures that urban institution will be compared only to urban institutions and nonurban institution will be compared only to nonurban institutions. It is reasonable to assume that the performance of the target institution is achievable since it is a weighted average of actual institutions. Finally, we note that, if Institution A were operating efficiently, then it would have placed 100% of its weight on itself and Institution A's target would be identical to Institution A.

Table 2 also shows the factor efficiencies for each input and each output, which are defined as the ratio of the target value to the actual value. The factor efficiencies of the inputs are bounded above by one while those for the outputs are bounded below by one. (The factor efficiencies of the outputs are often referred to as inverse factor efficiencies.) The factor efficiencies tell us that Institution A can reduce its operating expenses by 7.8% and its capital expenditures by 15.6% while increasing its total degrees granted by 10.8% and its research expenditures by 10.5%. We calculate the overall efficiency, sometimes called the radial efficiency, of Institution A as 100% − 7.8% = 92.2% since 7.8% is the smallest of these four percentages. This means that this institution can reduce all of its inputs by at least 7.8%, and it may be able to reduce other inputs even further.

## The Efficiency-Based Funding Model

We now present the linear programming formulation of the efficiency-based funding model. Let *n* be the number of institutions in the data set. The DEA literature refers to a service delivery unit, an institution in this context, as a *decision-making unit*, or DMU (Cook and

Seiford, 2009). Let $X_{ij}$ be amount of input $i$ consumed by DMU $j$, for $i = 1, 2, \ldots, I$ and $j = 1, 2, \ldots, n$. We note that inputs may enter a DMU at either Stage 1 or Stage 2. In our model, all inputs enter at Stage 1.

In particular, let $X_{1j}$ be the operating expenses of DMU $j$ while the remaining $X_{ij}$ represent other inputs, such as capital expenditures but others may be included. We need not measure these other inputs in currency units although we may as long as such funds are not fungible with operating expenses.

Let $Y_{rj}$ be the amount of output $j$ produced by DMU $j$, for $r = 1, 2, \ldots, R$ and $j = 1, 2, \ldots, n$. The outputs represent the production levels of the DMUs. We note that outputs may leave a DMU at either Stage 1 or Stage 2. In our model, research production exits from Stage 1 and the number of degrees granted at each level exit from Stage 2.

Let $Z_{mj}$ be the level of intermediate product $m$ at DMU $j$, for $m = 1, 2, \ldots, M$ and $j = 1, 2, \ldots, n$. An intermediate product is produced by Stage 1 and is consumed by Stage 2.

We emphasize that, while the choices of inputs, outputs, and intermediate products must capture the essence of each DMU's productive operations, it is often difficult to capture completely all of these quantities. In some cases, data are unavailable or a particular quantity may be inherently very difficult to measure. For example, research funding does not capture fully the research output of a university campus because it does not account for journal or book publications, conference presentations, and other forms of creative activity. Nonetheless, before we can use the model for funding purposes, we must make every effort to define all quantities as fully as possible. Below, we introduce the concept of a buffer to protect institutions against systematic underfunding due to difficulties of this type.

Let $S_{kj}$ be the value of site characteristic $k$ at DMU $j$, for $k = 1, 2, \ldots, K$ and $j = 1, 2, \ldots, n$. A *site characteristic* describes a feature of a DMU that influences its ability, favorably or unfavorably, to convert inputs into outputs. Each stage has its own set of site characteristics.

We need to answer two questions with respect to each site characteristic. First, does it belong in the model? We may have reasons to suspect that it has an influence on the ability of a DMU to operate efficiently but we may be unsure that the effect is real. Second, if the effect is real, is the site characteristic favorable or unfavorable? In some cases, there is little question about the favorable or unfavorable nature of the site characteristic, but in other cases it may not be clear.

We answer both questions by constructing a multiple regression model using operating expenses as the dependent variable and using all of the outputs and all of the site characteristics as potential independent variables. We can use a variable selection method, such as stepwise regression or best subsets regression, to assist in deciding which of the potential independent variables to keep in the model, and we should consider appropriate variable transformations – the natural logarithm is often helpful – to ensure that all the standard regression model assumptions are satisfied. We then use the site characteristics that remain in the regression model in the efficiency-based funding model and the signs of the coefficients reveal the nature of the site characteristics. If its coefficient is positive, then the site characteristic is unfavorable (higher values of the site characteristic are associated with higher operating expenses) and if its coefficient is negative, then the site characteristic is favorable (higher values of the site characteristic are associated with lower operating expenses).

We are now ready to present the input-oriented two-stage DEA model. We first present the formulation for Stage 1, then for Stage 2, and then for the entire institution. DEA requires the solution of all three linear programs for each DMU.

The Stage 1 linear program for DMU $d$, $d = 1, 2, \ldots, n$, is:

$$Min\ E_{1d} \tag{1}$$

subject to

$$\sum_{j=1}^{n} \lambda_j X_{ij} \leq E_{1d} X_{id} \ \ for\ i = 1, 2, \ldots, I \tag{2}$$

$$\sum_{j=1}^{n} \lambda_j Z_{mj} \geq Z_{md} \ \ for\ m = 1, 2, \ldots, M \tag{3}$$

$$\sum_{j=1}^{n} \lambda_j Y_{rj} \geq Y_{rd} \ \ for\ r = 1, 2, \ldots, R \tag{4}$$

$$\sum_{j=1}^{n} \lambda_j S_{kj} \leq or \geq or = S_{kd} \ \ for\ k = 1, 2, \ldots, K \tag{5}$$

$$\sum_{j=1}^{n} \lambda_j = 1 \tag{6}$$

$$\lambda_j \geq 0 \ \ for\ j = 1, 2, \ldots, n \tag{7}$$

$$E_{1d} \geq 0 \tag{8}$$

We observe that setting $\lambda_d = 1$, $\lambda_j = 0$ for $j \neq d$, and $E_{1d} = 1$ is a feasible, but not necessarily optimal, solution to the linear program for DMU $d$. This implies that $E_{1d}^*$, the optimal value of $E_{1d}$, must be less than or equal to 1. The optimal value, $E_{1d}^*$, is the *overall efficiency* of DMU *j*. The left-hand-sides of Equations (2)-(5) are weighted averages, because of Equation (6), of the inputs, intermediate products, outputs, and site characteristics, respectively, of the *n* DMUs. At optimality, that is with the $\lambda_j$ replaced by $\lambda_j^*$, we call the left-hand-sides of Equations (2)-(5) the *target inputs*, *target outputs*, *target intermediate products*, and *target site characteristics*, respectively, for DMU *d*.

Equation (2) implies that each target input will be less than or equal to the actual level of that input at DMU *d*. Similarly, Equations (3) and (4) imply that each target intermediate product and target output will be greater than or equal to the actual level of that intermediate product or output at DMU *d*.

The nature of each site characteristic inequality in Equation (5) depends on the manner in which the site characteristic influences efficiency. For a favorable site characteristic (larger values imply higher efficiency, on average), we use the less-than-or-equal to sign. For an unfavorable site characteristic (larger values imply lower efficiency, on average), we use the greater-than-or-equal to sign. In some cases, a site characteristic is measured using a 0-1 indicator variable to reflect membership in a category, such as "operating in an urban area." We may decide that, when we analyze an institution operating in an urban area, we will only allow other institutions operating in urban areas to appear with positive weight in the target DMU. In that case, we use the equal sign. Thus, Equation (5) implies that the value of each target site characteristic will be the same as or worse than the actual value of that site characteristic at DMU *d*.

Equation (6) ensures that the weights sum to one and allows us to interpret the target inputs, target outputs, and target intermediate products as weighted averages of the corresponding quantities at DMU *d*'s reference sites, that is, those for which $\lambda_j > 0$. In DEA terminology, this constraint indicates that the production process is variable returns to scale, meaning that the productivity of an additional unit of an input differs with the size of the institution.

Thus, the optimal solution to the Stage 1 linear program for DMU *d* identifies a hypothetical target Stage 1 DMU $d^*$ that, relative to DMU *d*, (a) consumes the same or less of every input, (b) produces the same or more of every intermediate product, (c) produces the same or more of every output, and (d) operates under the same or worse site characteristics. Moreover, the objective function expressed in Equation (1) ensures that the target DMU $d^*$ consumes input levels that are reduced as much as possible in across-the-board percentage terms.

The Stage 2 linear program for DMU *d*, $d = 1, 2, \ldots, n$, is:

$$Min\ E_{2d} \tag{9}$$

subject to

$$\sum_{j=1}^{n} \lambda_j X_{ij} \leq E_{2d} X_{id} \ \ for\ i = 1, 2, \ldots, I \tag{10}$$

$$\sum_{j=1}^{n} \lambda_j Z_{mj} \leq E_{2d} Z_{md} \ \ for\ m = 1, 2, \ldots, M \tag{11}$$

$$\sum_{j=1}^{n} \lambda_j Y_{rj} \geq Y_{rd} \ \ for\ r = 1, 2, \ldots, R \tag{12}$$

$$\sum_{j=1}^{n} \lambda_j S_{kj} \leq or \geq or = S_{kd} \ \ for\ k = 1, 2, \ldots, K \tag{13}$$

$$\sum_{j=1}^{n} \lambda_j = 1 \tag{14}$$

$$\lambda_j \geq 0 \ \ for\ j = 1, 2, \ldots, n \tag{15}$$

$$E_{2d} \geq 0 \tag{16}$$

Thus, the optimal solution to the Stage 2 linear program for DMU *d* identifies a hypothetical target Stage 2 DMU $d^*$ that, relative to DMU *d*, (a) consumes the same or less of every input, (b) consumes the same or less of every intermediate product, (c) produces the same or more of every output, and (d) operates under the same or worse site characteristics. Moreover, the objective function expressed in Equation (9) ensures that the target DMU $d^*$

consumes input and intermediate product levels that are reduced as much as possible in across-the-board percentage terms.

The institutional linear program for DMU $d$, $d = 1, 2, \ldots, n$, is:

$$Min\ E_d \tag{17}$$

subject to

$$\sum_{j=1}^{n} \lambda_j X_{ij} \le E_d X_{id}\ \ for\ i = 1, 2, \ldots, I \tag{18}$$

$$\sum_{j=1}^{n} \lambda_j Z_{mj} \ge Z_{md}^{*}\ \ for\ m = 1, 2, \ldots, M \tag{19}$$

$$\sum_{j=1}^{n} \lambda_j Y_{rj} \ge Y_{rd}^{*}\ for\ r = 1, 2, \ldots, R \tag{20}$$

$$\sum_{j=1}^{n} \lambda_j S_{kj} \le or \ge or = S_{kd}\ \ for\ k = 1, 2, \ldots, K \tag{21}$$

$$\sum_{j=1}^{n} \lambda_j = 1 \tag{22}$$

$$\lambda_j \ge 0\ \ for\ j = 1, 2, \ldots, n \tag{23}$$

$$E_d \ge 0 \tag{24}$$

In this formulation, the starred values on the right-hand-sides of (19) and (20) indicate that optimal values derived from the solution to the Stage 2 model. Thus, the institutional model determines how well Stage 1 could perform if Stage 2 minimized its use of inputs and intermediate products.

Thus, the optimal solution to the institutional linear program for DMU $d$, together with the optimal solution to the Stage 2 linear program for DMU $d$, identify a hypothetical target institution DMU $d^*$ that, relative to DMU $d$, (a) consumes the same or less of every input, (b) consumes the same or less of every intermediate product, (c) produces the same or more of every output, and (d) operates under the same or worse site characteristics. Moreover, the objective function expressed in Equation (17) ensures that the target DMU $d^*$ consumes input levels that are reduced as much as possible in across-the-board percentage terms.

Of course, to proceed we must assume that a DMU could in fact operate exactly as does DMU $d^*$. In the theory of production, this is the assumption, made universally by economists, that the production possibility set is convex. In this context, the *production possibility set* is the set of all vectors $\{\boldsymbol{X}_i, \boldsymbol{Y}_r | \boldsymbol{S}_k, \boldsymbol{Q}_m\}$ of inputs, outputs, site characteristics, and quality measures such that it is possible for a DMU to use input levels $\boldsymbol{X}_i$ to produce output levels $\boldsymbol{Y}_r$ under site characteristics $\boldsymbol{S}_k$ while achieving quality measures $\boldsymbol{Q}_m$. The convexity assumption assures that DMU $d^*$ is feasible and that it is reasonable to expect that DMU $d$ could modify its performance to match the performance of $d^*$.

We use the Premium Solver© add-in (Frontline Systems, Inc., Incline Village, NV) in Microsoft Excel© to solve the linear programs. We use three macros (one for each stage and one for the institution) written in Visual Basic for Applications© (VBA) to solve the $n$ linear programs sequentially and save the results within the spreadsheet.

## Computing the Reimbursement

Of particular interest for reimbursement purposes is $X_{1d}^{*} = \sum_{j=1}^{n} \lambda_j^{*} X_{ij}$, the optimal left-hand-side of Equation (17) when $i$ = 1, which represents the target operating expenses for DMU $d$ in the institutional model. We are tempted to conclude that DMU $d$ should receive the amount $X_{1d}^{*}$ as its reimbursement. However, we must recognize that our model, like all models, is imperfect. For example, an individual DMU may argue that our model excludes a site characteristic that affects them directly. Moreover, can we be convinced that we have completely measured the quality and safety of each DMU's performance? Surely, there will be measurement errors in our data. The presence of these objections can be sufficient to result in the rejection of the entire funding approach.

In addition, we believe that requiring a DMU to achieve 100% efficiency in order to receive full reimbursement is somewhat draconian. By analogy, we do not require a student to have a 100% average in a course to receive a final grade of A, the highest performance evaluation. We normally require the student's average to equal or exceed, perhaps, 90% to qualify for a final grade of A.

Therefore, we set the DMU's (maximum) reimbursement equal to a value greater than its target operating expenses by an amount called the *buffer*. We set the buffer equal 10% of the DMU's target operating expenses, although this is a policy decision and other ways to compute the buffer are possible. We believe that a 10% buffer adequately compensates for possible shortcomings in the model and makes the model's performance expectations more reasonable.

In addition, the state has no reason to fund an institution for expenses that the institution did not incur. Therefore, we set the reimbursement for DMU $d$ equal to the smaller of its actual operating expenses and $1.1 * X_{1d}^{*}$.

## Data

We retrieve all data, except for CPI-U, from the Integrated Postsecondary Education Data Systems (IPEDS) web site hosted by the U.S. Department of Education, National Center for Education Statistics. All data are for 2006-07 academic year. We started with 675 public four-year colleges and universities in the U.S. but needed to drop several institutions due to missing data, leaving 362 institutions available for analysis.

We use the annual CPI-U for the year 2006, using 1982-84 as the base, for the census region in which the institution is located. We retrieve the CPI-U data from the U.S. Department of Labor, Bureau of Labor Statistics.

## Results

### *Reimbursement Results*

We find that 144 of the 362 institutions (39.8%) have factor efficiencies equal to one for operating expenses in the institutional model. For these institutions, their actual and target operating expenses are equal and they would receive full reimbursement of their operating expenses. We find that, for an additional 31 institutions (8.6%), their actual operating expenses lie within the 10% buffer of their target operating expenses and they too would receive full reimbursement of their operating expenses. Thus, in total, 175 of the institutions (48.3%) would receive full reimbursement of their operating expenses.

Figure 2 shows the histogram of the operating expenses factor efficiencies of the institutions not on the efficient frontier in the institutional model. Figure 3 shows the histogram of the funding percentages of the institutions that would not receive full reimbursement.

* * * Figure 2 here * * *

* * * Figure 3 here * * *

Table 3 shows the summary statistics for the key efficiency and reimbursement variables. All dollar values are in millions. The lower quartile for the reimbursement percentage equals 79.9% and the median equals 98.4%, meaning that 75% of the institutions would receive at least 79.9% of their operating expenses and half would receive at least 98.4% of their operating expenses.

* * * Table 3 here * * *

Figure 4 shows the relationship between operating expenses and funding percentage. Figure 4 includes a locally weighted regression (LOESS) curve fit that reveals that there is little relationship between these two variables, as desired.

* * * Figure 4 here * * *

The 362 institutions spent a total of $96.74 billion and they would receive a total reimbursement of $88.02 billion. Thus, the efficiency-based funding formula would reduce state government expenditures on higher education by $8.72 billion, or approximately 9.0%.

### *Efficiency Results*

Table 4 shows the number of institutions that are efficient and the number of institutions that are inefficient in Stage 1 and Stage 2, by Carnegie Classification Code. We find that 39 of the 362 institutions (10.8%) are efficient in both stages, 103 institutions (28.5%) are efficient in Stage 1 but not Stage 2, 31 institutions (8.6%) are efficient in Stage 2 but not Stage 1, and 189 institutions (52.2%) are efficient in neither stage. In total, 142 institutions (39.2%) are efficient in Stage 1 while 70 institutions (19.3%) are efficient in Stage 2 (P-value < 0.00005 in a McNemar's Test). Thus, institutions are roughly twice as likely to be efficient in Stage 1 relative to Stage 2.

* * * Table 4 here * * *

Chi-square tests shows that being efficient in Stage 1 and being efficient in Stage 2 are each unrelated to the institution's Carnegie Classification Code (P-value = 0.2003 for Stage 1 and 0.6065 for Stage 2). This confirms that the incorporation of Carnegie Classification Code as a site characteristic successfully removes this factor from the efficiency calculations, as desired.

Figures 5, 6, and 7 show the histograms of the Stage 1 efficiency scores, the Stage 2 efficiency scores, and the institutional efficiency scores for those institutions that are inefficient. Table 5 shows descriptive statistics for these efficiency scores. Consistent with our observations above, we observe that Stage 1 efficiency scores are generally higher than Stage 2 efficiency scores. A matched-pairs t-test shows that the mean difference of 7.4% is highly statistically significant (P-value < 0.00005), a Wilcoxon Rank Sum test shows that the distributions are distinct (P-value < 0.00005), and a sign test shows that the median difference of 11.0% is also highly statistically significant (P-value < 0.00005). Thus, we have further evidence that institutions are more efficient in Stage 1 than they are in Stage 2.

* * * Figure 5 here * * *

* * * Figure 6 here * * *

* * * Figure 7 here * * *

* * * Table 5 here * * *

### *Case Studies*

We illustrate the nature of the information that the methodology makes available to each institution and show how that information might be helpful to an institution as it seeks to improve its reimbursement. For institutions that are 100% efficient in both stages, the model offers no guidance.

Consider the case of one (unnamed) institution that is 100% efficient in Stage 2 but 73.2% efficient in Stage 1. The Stage 1 analysis indicates that its target institution has core expenses that are 26.8% lower and capital expenditures that are 44.7% lower than those incurred at the given institution. This institution has an institutional efficiency of 76.4% and it would receive 84.0% of its funding. The guidance for this institution is to search for ways to decrease its operating expenses and its capital expenditures without jeopardizing its conversion of enrolled students into alumni.

Consider the case of one (unnamed) institution that is 100% efficient in Stage 1 but 22.7% efficient in Stage 2. The Stage 2 analysis indicates that its target institution offered the same number of degrees but did so with 77.3% fewer FTE students enrolled. The institutional analysis shows that this institution's target spends 19.5% less and that this institution would receive 88.5% of its funding. The guidance for this institution would be to identify the reasons for the low number of degrees granted given its FTE enrollment. The additional students who do not graduate are the cause of its reduced funding. The institution needs to either reduce the number of enrolled students or increase the number of students who receive degrees.

Consider the case of one (unnamed) institution that is 100% efficient in Stage 1 but 73.6% efficient in Stage 2. The Stage 2 analysis indicates that its target institution offered 8.0% more masters degrees and 26.8% more doctorate degrees, and did so with 26.4% fewer FTE students enrolled. However, the institutional analysis shows that, given the institution's research output, its target institution incurs the same total operating expense. Thus, this institution has an institutional efficiency of 100% and it would receive full funding. There is no evidence that this institution could save money even if it enrolled fewer students while maintaining its research output. A likely explanation is that, to produce its level of research output, the institution requires its current number of faculty members, who also teach, thereby providing ample course opportunities for students. Nonetheless, the guidance for this institution is to examine the reasons why its graduate students are earning degrees in fewer numbers than expected.

Consider the case of one (unnamed) institution that is inefficient in both stages. The Stage 1 analysis shows that the institution's target spends 15.9% less in operating expenses and 34.6% less in capital expenditures. The Stage 2 analysis shows that the institution's target grants the same number of degrees but does so by enrolling 34.5% fewer FTE students. The institutional analysis shows that this institution's target spends 15.8% less in operating expenses and that this institution would receive 92.7% of its funding. The guidance for this institution is (1) to determine how to reduce its operating expenses and its capital expenditures, and (2) to determine either how to reduce the number of enrolled students or to increase the number of degrees granted.

## Discussion and Conclusion

Funding mechanisms influence behavior, and therefore a government agency must design its funding mechanism to ensure that it provides incentives that are consistent with the agency's overall mission. Incremental methods, activity-based methods, and outcome-based methods, while sensible on the surface, may in fact provide incentives that have the opposite effect in higher education. Efficiency-based methods, on the other hand, provide institutions with the incentive to reduce costs while increasing positive outcomes and maintaining high quality standards. Administrators, being in the best position to identify sources of inefficiency on their own campuses, can achieve these objectives by seeking out and eliminating waste and by implementing better management practices.

In addition, as individual institutions become more efficient over time, the efficient frontier will "raise the bar" for all institutions. Thus, while efficiency is measured each year relative to the performance of all institutions in that year, we should expect that last year's performance will not necessarily provide an institution with the same reimbursement this year. In short, institutions will need to continue to improve to avoid falling behind by an ever-advancing efficient frontier.

We have demonstrated how to apply efficiency-based funding to state university systems. The results are plausible. If each state used our model, nearly half of all campuses would receive full funding and three-quarters would receive at least 80%. Overall, public funding for state universities would decline by 9%. We would advise states to implement the new funding mechanism over a period of several years so that any cuts would be easier to absorb.

There is no single set of defined inputs and outputs in assessing higher education performance (Kuah and Wong, 2011). While we believe that our model captures the appropriate inputs, intermediate products, outputs, and site characteristics, each state should consider using those that best represent its state university system and its managerial goals. We recognize that this is a significant challenge in the complex world of higher education.

Some precedence suggests that efficiency-based funding can be politically acceptable and successfully implemented. In 1994, North Carolina instituted an efficiency-based funding mechanism for pupil transportation. It was the first such model in the country and it continues in use today. In 1993, one year before the mechanism was formally in place, but three years after its planned implementation was announced, the state was already saving $17.7 million per year, or about 7%, on pupil transportation operating cost (Sexton, *et al.* 1994). As of the 2000-01 institution year, North Carolina was operating nearly 900 fewer buses than it would have had the pre-1991 trend continued. Over that same period, the institution buses in North Carolina traveled over 224 million miles fewer than they would have had the pre-1991 trend continued, resulting in additional savings of between $18 million and $30 million per year in bus replacement costs

(North Carolina Department of Public Instruction). This has occurred with no increase in the institution bus accident rate. Based on North Carolina's success, Washington State has developed a formula very much like the one described here and is using it now for management purposes with the option to implement it as a funding mechanism in the future. We recognize that higher education is a much more complex operation than pupil transportation and that the challenges associated with the development and implementation of an efficiency-based funding formula for colleges and universities will be considerable. However, the North Carolina experience demonstrates that state legislatures can adopt efficiency-based funding formulas and, when they do, the effects can be quite beneficial.

As states face increasingly dire budget shortfalls and state institutions of higher education struggle to maintain enrollment, research productivity, and educational quality, we propose that state legislators consider a new approach to higher education funding. We believe that an efficiency-based approach holds significant promise for both the states and for their universities.

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## Tables

**Table 1: Recoded Carnegie Classification Codes (CCC).**

| Recoded Value | CCC | Description |
|---|---|---|
| **Research (R)** | | 126 Institutions (34.8%) |
| | 16 | Research Universities (high research activity) |
| | 15 | Research Universities (very high research activity) |
| | 17 | Doctoral/Research Universities |
| **Masters (M)** | | 166 Institutions (45.9%) |
| | 18 | Master's Colleges and Universities (larger programs) |
| | 19 | Master's Colleges and Universities (medium programs) |
| | 20 | Master's Colleges and Universities (smaller programs) |
| **Baccalaureate (B)** | | 63 Institutions (17.4%) |
| | 22 | Baccalaureate Colleges--Diverse Fields |
| | 21 | Baccalaureate Colleges--Arts & Sciences |
| | 23 | Baccalaureate/Associate's Colleges |
| **Associate (A)** | | 2 Institutions (0.55%) |
| | 12 | Associate's--Public 4-year Primarily Associate's |
| | 3 | Associate's--Public Rural-serving Large |
| | 2 | Associate's--Public Rural-serving Medium |
| | 11 | Associate's--Public 2-year colleges under 4-year universities |
| | 7 | Associate's--Public Urban-serving Multicampus |
| | 6 | Associate's--Public Urban-serving Single Campus |
| | 1 | Associate's--Public Rural-serving Small |
| | 4 | Associate's--Public Suburban-serving Single Campus |
| **Special Focus (S)** | | 3 Institutions (0.83%) |
| | 25 | Special Focus Institutions--Medical schools and medical centers |
| | 26 | Special Focus Institutions--Other health professions schools |
| | 31 | Special Focus Institutions--Schools of law |
| | 30 | Special Focus Institutions--Schools of art, music, and design |
| | 27 | Special Focus Institutions--Schools of engineering |
| | 28 | Special Focus Institutions--Other technology-related schools |
| **Other (O)** | | 2 Institutions (0.55%) |
| | -3 | Not applicable, not in Carnegie universe (not accredited or nondegree-granting) |
| | 33 | Tribal Colleges |
| | 0 | Not classified |

**Table 2: Hypothetical DEA results for Institution A.**

| Institution | Weight | Op Expenses | Cap Expend | Degrees | Research | CPI-U | Urban |
|---|---|---|---|---|---|---|---|
| **Institution A** | --- | $900 | $64 | 3,060 | $191 | 200 | 1 |
| **Institution B** | 60% | $1,000 | $60 | 4,400 | $270 | 200 | 1 |
| **Institution C** | 30% | $100 | $20 | 500 | $30 | 195 | 1 |
| **Institution D** | 10% | $2,000 | $120 | 6,000 | $400 | 215 | 1 |
| **Institution A's Target** | **---** | **$830** | **$54** | **3,390** | **$211** | **200** | **1** |
| **Factor Efficiencies** | | 92.2% | 84.4% | 110.8% | 110.5% | | |

**Table 3: Summary statistics for the key efficiency and reimbursement variables. All dollar values are in millions.**

| | Overall Efficiency | Operating Expenses Factor Efficiency | Actual Operating Expenses | Target Operating Expenses | Reimbursement | Reimbursement Percent |
|---|---|---|---|---|---|---|
| **N** | 362 | 362 | 362 | 362 | 362 | 362 |
| **Mean** | 85.3% | 85.0% | $267.2 | $232.9 | $219.1 | 89.1% |
| **SD** | 16.1% | 16.4% | $372.3 | $349.6 | $344.2 | 14.4% |
| **Minimum** | 34.8% | 34.8% | $9.0 | $9.0 | $8.1 | 38.2% |
| **Lower Quartile** | 72.9% | 72.6% | $61.3 | $48.8 | $42.7 | 79.9% |
| **Median** | 90.6% | 89.4% | $121.9 | $106.4 | $99.4 | 98.4% |
| **Upper Quartile** | 100.0% | 100.0% | $292.6 | $256.4 | $245.7 | 100.0% |
| **Maximum** | 100.0% | 100.0% | $2266.9 | $2266.9 | $2266.9 | 100.0% |

**Table 4: Cross-tabulation of the number of institutions that are efficient and the number of institutions that are inefficient in Stage 1 and Stage 2, by Carnegie Classification Code.**

| | | Efficient in Stage 2 | Not Efficient in Stage 2 | Row Totals |
|---|---|---|---|---|
| **Efficient in Stage 1** | Research | 14 | 40 | 54 |
| | Masters | 11 | 44 | 55 |
| | Baccalaureate | 7 | 19 | 26 |
| | Associate | 2 | 0 | 2 |
| | Special Focus | 3 | 0 | 3 |
| | Other | 2 | 0 | 2 |
| | **Cell Totals** | **39** | **103** | **142** |
| **Not Efficient in Stage 1** | Research | 10 | 62 | 72 |
| | Masters | 15 | 96 | 111 |
| | Baccalaureate | 6 | 31 | 37 |
| | Associate | 0 | 0 | 0 |
| | Special Focus | 0 | 0 | 0 |
| | Other | 0 | 0 | 0 |
| | **Cell Totals** | **31** | **189** | **220** |
| **Column Totals** | Research | 24 | 102 | 126 |
| | Masters | 26 | 140 | 166 |
| | Baccalaureate | 13 | 50 | 63 |
| | Associate | 2 | 0 | 2 |
| | Special Focus | 3 | 0 | 3 |
| | Other | 2 | 0 | 2 |
| | | **70** | **292** | **362** |

**Table 5: Descriptive statistics for the Stage 1, Stage 2, and institutional efficiency scores.**

| | Stage 1 | Stage 2 | Institution |
|---|---|---|---|
| N | 362 | 362 | 362 |
| Mean | 86.3% | 78.8% | 85.3% |
| Standard Deviation | 15.1% | 16.4% | 16.1% |
| Minimum | 36.4% | 22.7% | 34.8% |
| First Quartile | 76.6% | 67.7% | 72.9% |
| Median | 90.4% | 79.4% | 90.6% |
| Third Quartile | 100.0% | 94.4% | 100.0% |
| Maximum | 100.0% | 100.0% | 100.0% |

## Figures

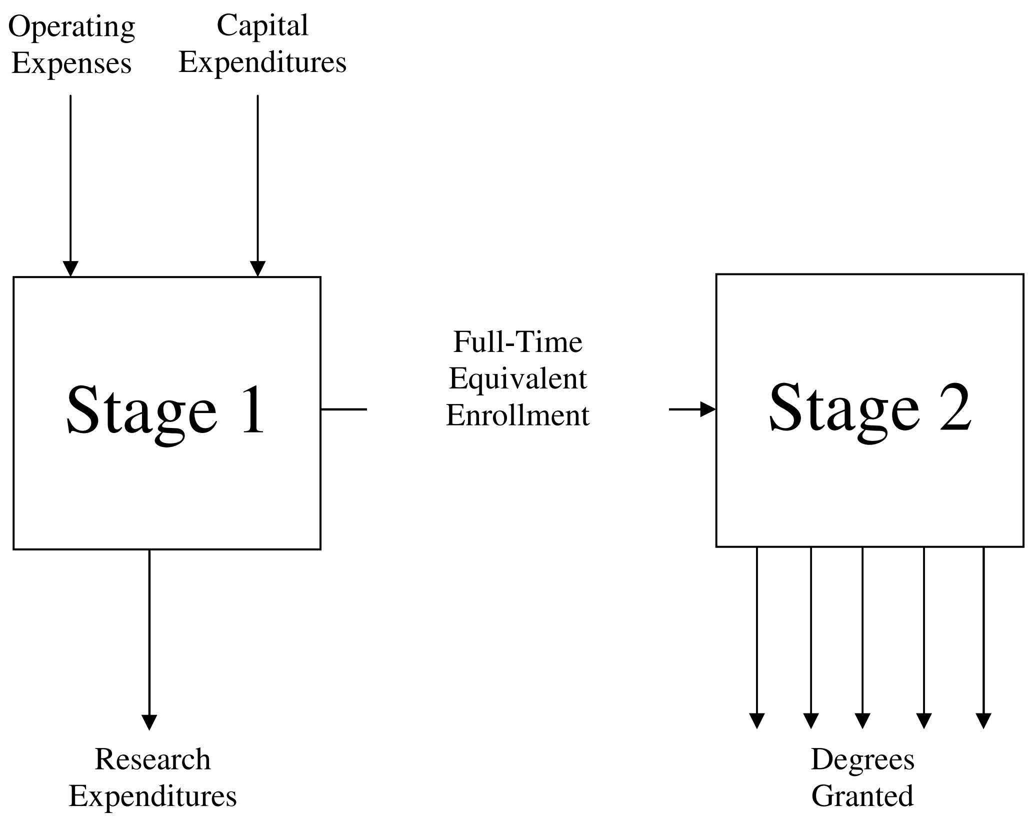


**Figure 1: Two-stage DEA model of public four-year colleges and universities.**

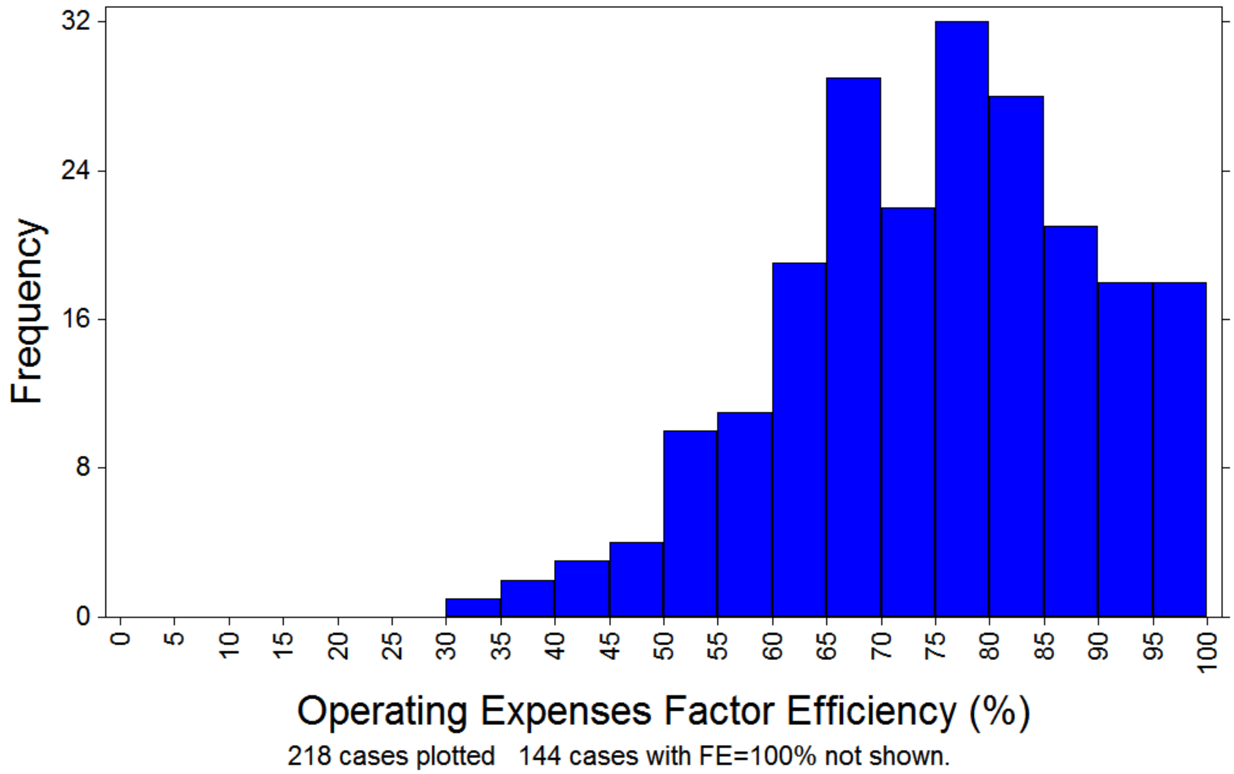


**Figure 2: Histogram of the operating expenses factor efficiencies of the institutions not on the efficient frontier.**

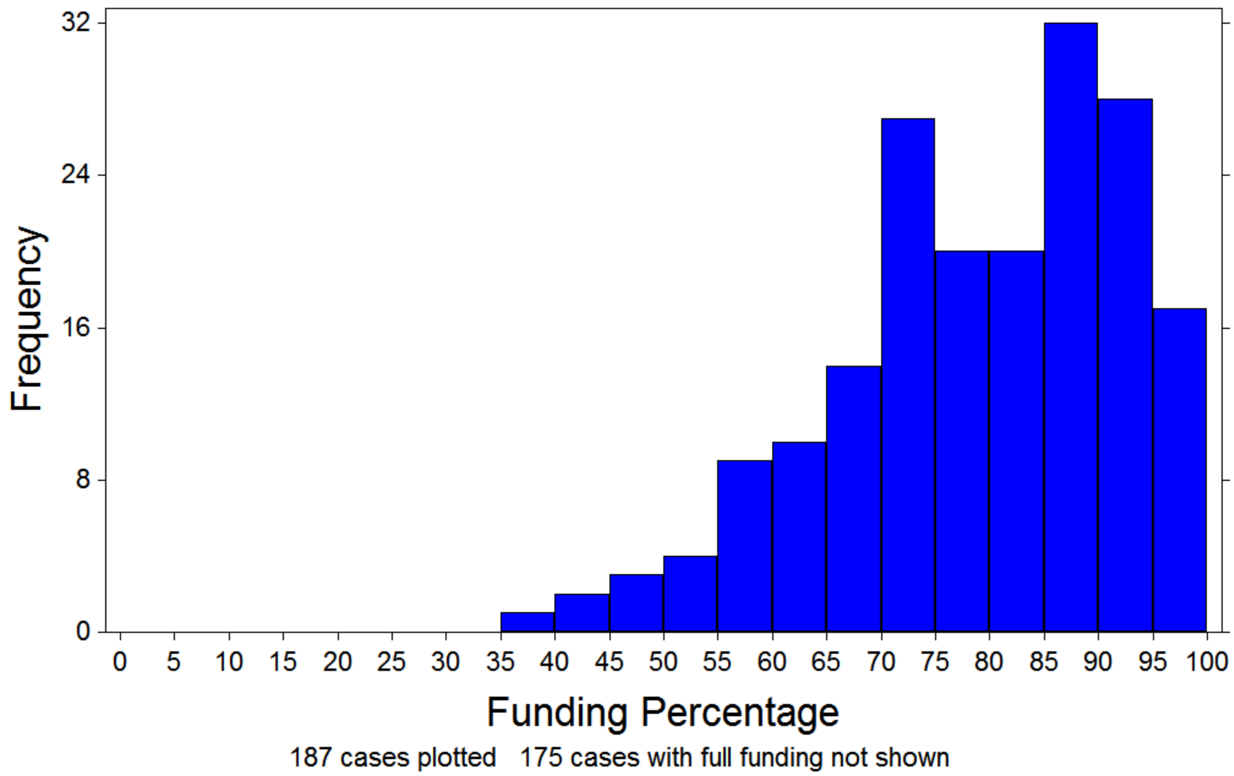


**Figure 3: Histogram of the funding percentages of the institutions that receive less than full funding.**

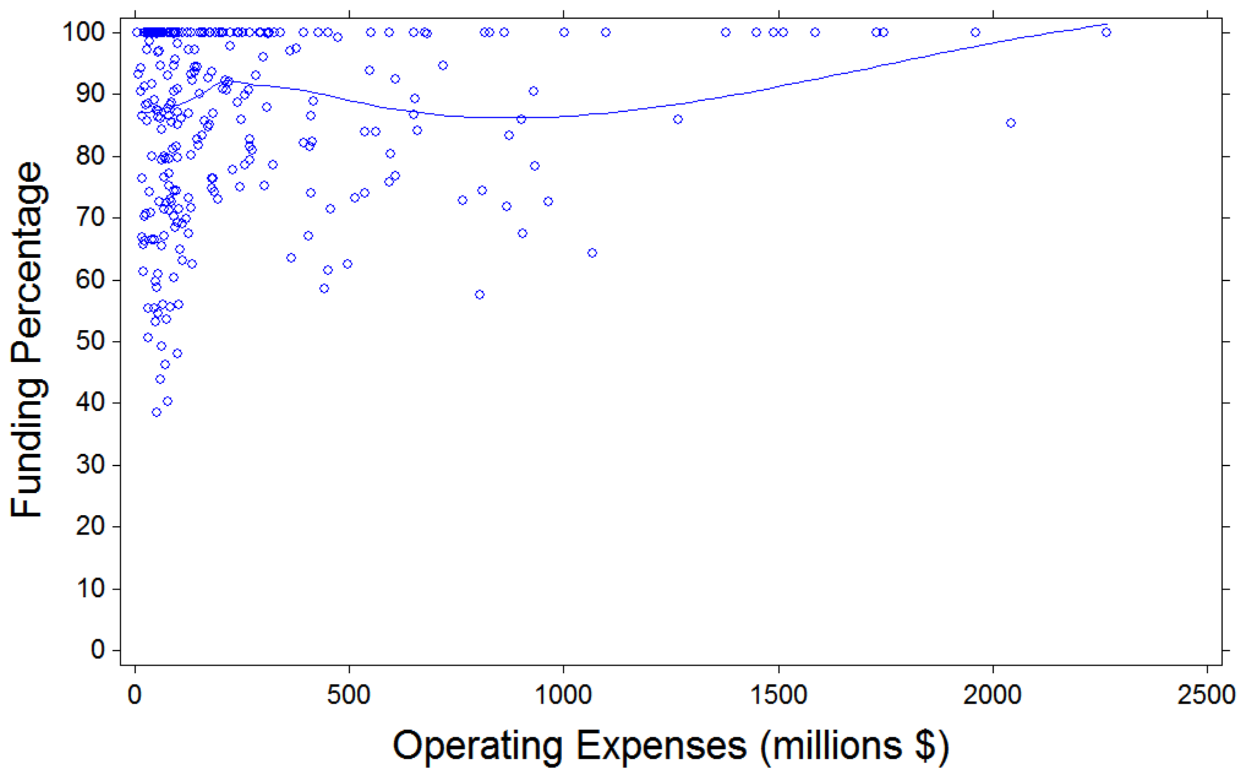


**Figure 4: The relationship between actual operating expenses (in millions of dollars) and funding percentage. Also shown is the linear LOWESS smooth with alpha=0.75.**

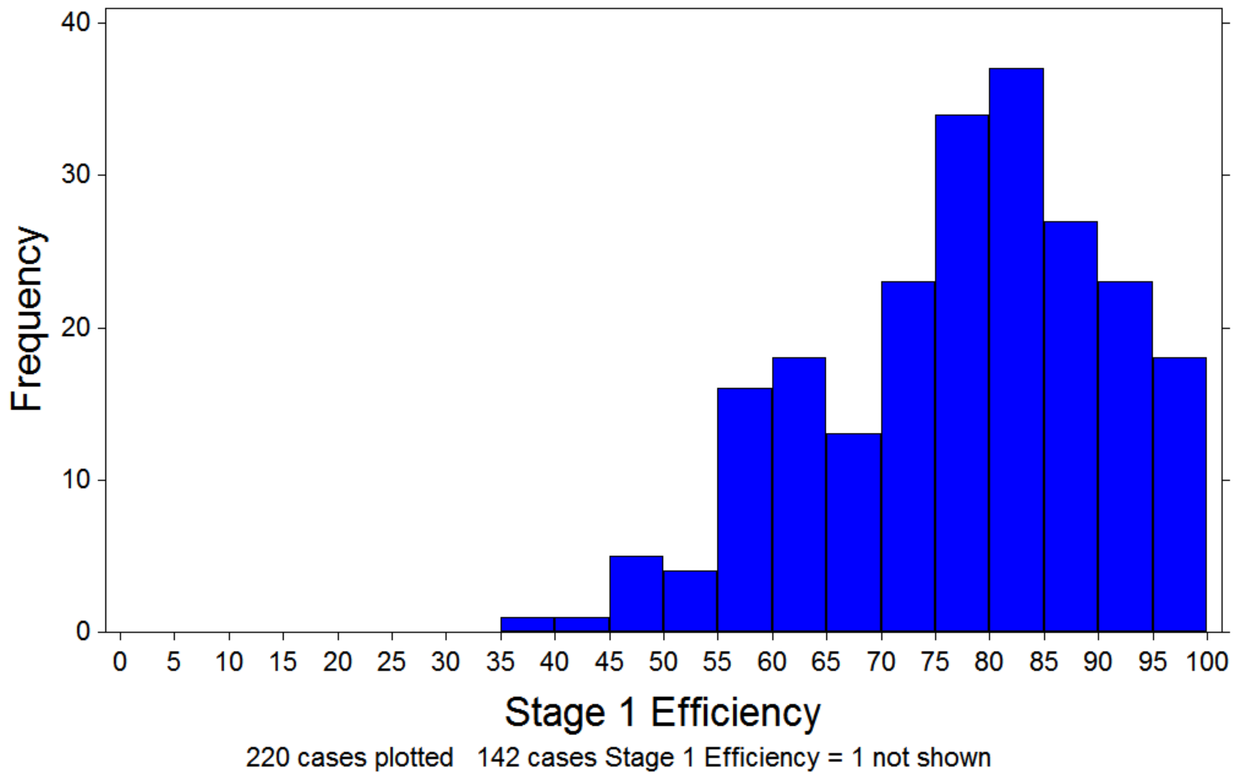


**Figure 5: Histogram of the Stage 1 efficiency scores for those institutions that are inefficient in Stage 1.**

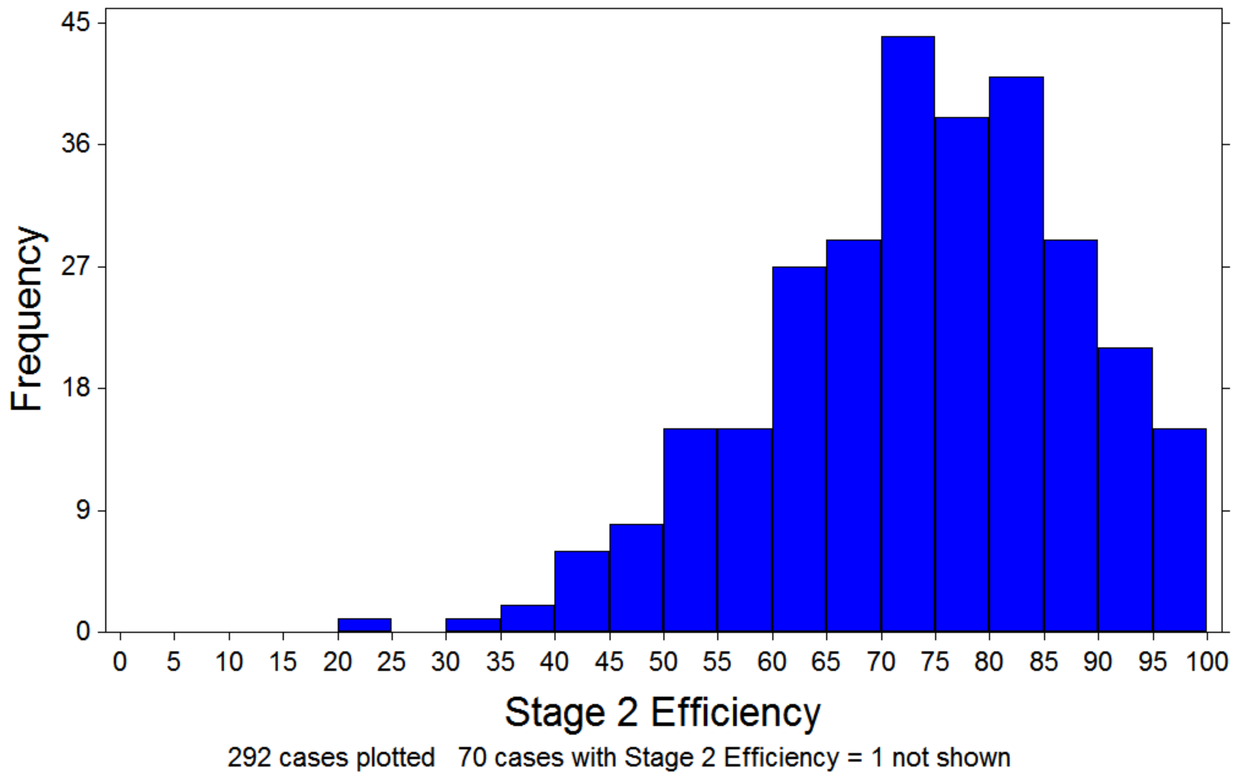


**Figure 6: Histogram of the Stage 2 efficiency scores for those institutions that are inefficient in Stage 2.**

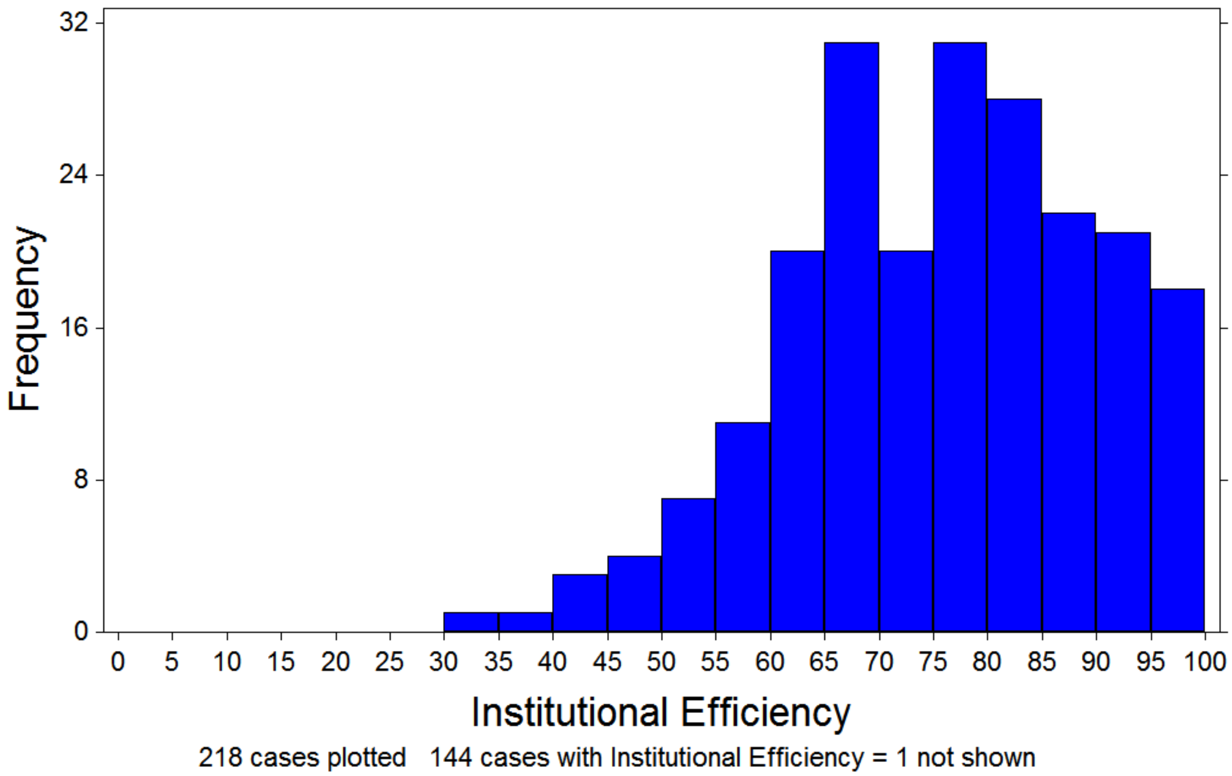


**Figure 7: Histogram of the institutional efficiency scores for those institutions that are inefficient overall.**