Identifying the Best Buys in U. S. Higher Education

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Abstract

Consumers of higher education face a bewildering array of product and price combinations. We compare U. S. institutions with a Data Envelopment Analysis (DEA) multi-factor frontier using 2000-2001 data for 1,188 four-year institutions of higher education. The input is net price or tuition, fees, room, and board less per student financial aid. Outputs include SAT score, athletic expenditures, instructional expenditures, value of buildings, dorm capacity, and student body characteristics. The DEA efficiency scores indicate the distance of each institution from the "best buy" frontier, providing an objective means of ranking institutions as the best buys in higher education.

Key words: Education, Data Envelopment Analysis, Comparative advantage

JEL category: I20

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Introduction

The age of the Internet has brought instant information for consumers regarding prices, qualities, and availability of seemingly unlimited product varieties. It is common to find recommendations for the "best buy" in whatever category the consumer desires. Rankings of U.S. higher education institutions have been published in several magazines, including *Consumers Digest*, *Forbes* and *U.S. News and World Report*. The intent of such rankings is to sell magazines, however, and they have generated a great deal of controversy (Burness, 2008). In addition to the U.S. rankings there are many international rankings which have produced no less discussion. This paper offers a new, perhaps more objective approach to assist in the very complicated consumer choice of a higher education institution.

Prospective students face a bewildering array of institutional characteristics: public, private, religious affiliated, high admission standards, minimal admission standards, Nobel Prize winning faculty, commuter school with adjunct faculty, single gender, coeducational, urban, pastoral campus, major sports powers, and many others. In addition, each institution has an associated price tag reflecting not only its product dimensions, but the student applicant's individual characteristics such as academic credentials, family income, and other qualities. How is the applying student to choose?

We propose to identify the "best buys" in higher education using a multi-factor frontier based on Data Envelopment Analysis (DEA). Theoretical analysis of the economics of higher education institutions yields an efficiency measure relative to a minimum net-price, multiple-output frontier. Data on 1,188 four-year institutions of higher education in the United States are collected from the Integrated Post-Secondary Education Data System (IPEDS) for the 2000-2001 academic year and DEA is used to identify the best practice net-price frontier using various measures of outputs (qualities). Net prices are calculated as the published tuition, fees, room and board less the per student average state and institutional financial aid. The quality or output measures that prospective students may value include peer academic ability, faculty quality, intercollegiate athletics, campus physical facilities, and student body characteristics. The DEA efficiency scores then indicate the distance of each institution from the "best buy" frontier, providing an objective means of ranking institutions as the best buys in higher education over this set of outputs. The results suggest a clustering of best buys in the Sunbelt states, especially the southeastern United States.

This method also has policy applications as a means to evaluate the relative "expensiveness" of institutions by accounting for both price (or cost) and quality dimensions. Under the cost reporting requirements of the recently renewed U. S. Higher Education Act, for example, the institutions with the highest tuition increases must report on the factors causing the increase to the education secretary (Field, 2008). Even with large changes in net prices, high quality institutions could be "underpriced" and low quality "overpriced," or numerous other combinations, but attention to tuition increases alone ignores this quality dimension. The frontier approach that we demonstrate here has the advantage of comparing each institution against its peers, in the sense of those producing similar output proportions, in calculating the efficiency measure. Schools emphasizing academics over athletics are compared to similar institutions and not to schools emphasizing major conference sports teams, for example. DEA calculates an efficiency score for each institution measured against its peers in the observed outputs.

The paper begins with a cursory review of the literature dealing with several aspects of the issues examined: the DEA methodology, the application of the methodology to higher education, the matter of quality in educational institutions, and the consideration of quality in DEA models. A second section presents a theoretical motivation for the economics of the higher education institution as a multi-product enterprise and for using a net-price frontier. A third section describes the data drawn principally from the National Center for Education Statistics' Integrated Post-Secondary Education Data System, a rich but challenging source for data on higher education. Section 4 discusses the DEA methodology and Section 5 presents the results and the interpretation of those results. Finally, there is a summary and conclusion.

1. Literature Review

Ranking colleges and universities on the bases of many criteria is a significant industry. There are rankings by news media such as *Forbes* (2009), *U.S. News & World Review* (2009) and *The Washington Monthly* (2009) or the more specialized *Princeton Review* (2009); there are rankings by academic discipline and for minority groups; and, of course, there are rankings of athletic teams. In addition, there are international rankings as well, for example *The Good University Guide* by *The Times* of London, U.K. and the Shanghai rankings of "world class universities" by Shanghai Jiao Tong University. Very simply, rankings of institutions of higher education are available based on many different criteria.

These rankings have created a blizzard of controversy and it will not be reviewed here. A very brief listing of this literature might include Billaut et al. (2009), Dill and Soo (2005), Ehrenburg (2003), Liu and Cheng (2005), Turner (2008), and van Raan (2005), but for a much more complete bibliography see the College Ranking Bibliography at the University of Illinois at Urbana-Champaign University Library.

Recently, the use of DEA for comparing institutions made the front page of *The Chronicle of Higher Education* (Glenn, 2007). This article described Economists Robert Archibald's and David Feldman's (2008) use of DEA to construct an efficient frontier for 187 institutions based on graduation rates, SAT scores, high school grades, percent full time faculty, and expenditures per undergraduate. Thirty-five institutions were found to define the frontier. Thirty-nine "anomalies" were also identified: institutions whose DEA efficiency scores diverged from their predicted performance using a regression technique similar to that underlying the popular *U. S. News* rankings. We attempt to extend this general approach to more institutions, more institutional characteristics, and the concept of best price.

Various approaches to evaluating institutions have appeared in the academic literature. A 2004 NBER paper (Avery et al., 2004) develops a ranking of more than 100 highly selective U.S. colleges and universities through a revealed preference methodology. Applying a statistical technique for ranking players in chess and tennis tournaments to survey information from 3,240 high achieving students, they find a ranking by matching one institution against other institutions in a group to which the survey respondents applied, were accepted, and matriculated. The ranking derives from the unspecified criteria that these students use in making their decisions. The methodology assumes an underlying set of decision criteria even though these are not articulated by the decision-makers.

Other approaches to the decision of which college to attend include labor market influences, i.e., the influence of wage incentives on career and college choice (Behrman et al., 1998); the college application decision process, i.e., what influences the decision to apply to a particular institution or type of institution (Hoxby, 2004; DesJardin et al., 1999); and the impact of high school quality on the college decision (Strayer, 2002).

The data envelopment analysis (DEA) technique used below has been widely applied to many questions and contexts. For a comprehensive discussion of DEA see Cooper et al. (2007). Emrouznejad (2008) provides a DEA bibliography covering virtually every sort of application and aspect of the technique. Many applications of DEA to the study of colleges and universities examine the efficiency of institutions (Abbott and Douccouliagos, 2003; Athanassopoulos and Shalle, 1997; Flegg and Allen, 2007; Johnes, 2006) and departments within universities (Tauer et al, 2007). DEA analyses of colleges and universities have been criticized for the effect of measurement error, a likely problem with data from self-reported surveys (Van Biesebroeck, 2007). Nevertheless, others have found that university level studies, particularly those utilizing panel data, are reliable (Johnes 2006; Ruggiero, 2006). Another group of DEA applications assesses the efficiency of components of larger universities, i.e., departments (Gimenez and Martinez, 2006; Johnes and Johnes, 1993, 1995).

There is a DEA literature dealing with the ranking of universities. A representative piece is that by Sarrico et al. (1997) which compares the *Times* (of London) *Good University Guide* with a DEA ranking of the same UK institutions. The paper concludes that while the newspaper's ranking matches well with prospective students of a particular type it does not for students with different perspectives. A similar application of DEA is found in Bougnal and Dulá (2006) which compares a ranking of U.S. research universities published by the University of Florida's *TheCenter* with a DEA ranking. Based on ten decision criteria the authors find comparable though not identical rankings. The authors conclude that DEA offers an alternative ranking methodology that avoids some of the problems associated with *ad hoc* models used by the typical ranking producers.

In the present paper, DEA is used to address the issue of valuing the non-traded attributes of colleges and universities, or the quality of the institutions' "product," rather than the cost or technical efficiency of organizations and enterprises. There are other approaches to assessing the value of quality in education. (Buss et al., 2004; Mayer-Foulkes, 2002) There are also DEA studies that incorporate quality in their analysis (Lewis et al., 2007; Marshall and Shortle, 2005; Yu et al., 2007). We apply the DEA methodology to identify an efficiency frontier encompassing a number of institutional attributes and the net price of admission.

2. Theoretical motivation

Higher education institutions are modeled as competing, differentiated product producers as in Rosen (1974). Rosen treats producers as profit maximizers, but this is problematic for non-profit higher education institutions, whether public or private. Consequently, non-profit institutions are assumed to maximize a value function over a vector of qualities, Z, subject to a break-even, zero profit condition (Martin 2004; Tiffany and Ankrom 1998):

$$\text{Max } V(Z) \qquad \text{s.t. } C(Q, Z) - [P(Z)Q + N] = 0 \qquad (1)$$

where C is a cost function, $C_Q, C_{zi} > 0$, N is non-tuition funding from endowments or state appropriations, P(Z) is the market price of quality vector $Z = [z_1, z_2, \ldots, z_n]$, and Q is the quantity "sold." The first order conditions are

$$V_{zi} = \lambda[C_{zi} - P_{zi}Q], \quad \text{for all i; or } P_{zi} = \{C_{zi} - [V_{zi}/ \lambda]\}/Q$$

$$\text{and } C(Q, Z) - [P(Z)Q + N] = 0, \qquad \text{or } P(Z) = [C(Q, Z) - N]/Q \qquad (2)$$

These imply that the marginal cost of any quality, z_i, may exceed its marginal price, P_{zi}, when that quality is positively valued by the institution. The constraint requires the funding of the resulting "subsidy" by foregone profits and/or non-tuition revenues. An institution may "buy" good students by offering subsidies (financial aid) in this way (Clotfelter, 1999; Winston, 2003, 2004; Epple et al., 2003). The constraint also imposes "net average cost pricing" as the market price of Z must equal the net cost (C – N) per unit quantity (student).

If we observe the net revenue per student for each higher education institution, then this defines a point reflecting the net cost per student for the collection of product qualities or "outputs" chosen by that institution. A relatively conventional (net) cost frontier (Kumbhakar and Lovell, 2000) can be defined from (3) over these "outputs" as:

$$c(Q, Z, N) = [C(Q, Z) - N]/Q = P(Z) \qquad (4)$$

where $C(Q, Z) = \min_x\{w^T x : x \text{ can produce } (Q, Z)\}$.

Similarly, efficiency measures relative to this frontier may be defined in two ways. The first forms the ratio of the efficient (or best practice) net-average-cost (or net price) to the actual observed net-average-cost (net price) for each institution, holding the output vector constant:

$$E = [c(Q, Z, N)]/[(w^T x - N)/Q] = [\min P(Z)]/[P_i(Z)] \quad (5)$$

Here the net price of each institution is observed and a minimum net-price frontier, equivalent to a minimum net-average-cost frontier, is constructed. The actual price charged by each institution relative to this best practice frontier is used to calculate an "efficiency" measure for each institution.

A second efficiency measure is defined as the proportion by which the efficient output vector Z* is deflated to arrive at the observed output vector Z_i, moving along a ray from the origin, holding the net price constant:

$$\lambda_i = (Z_i/Z^*)$$

for $P_i(Z_i) = P_m(Z^*)$, where $P_m(Z^*)$ is on the frontier and $Z_i = \lambda_i Z^*$. This latter measure (λ_i) is equivalent to the Data Envelopment Analysis efficiency score calculated below.

Note that evaluating each institution along the ray from the origin that contains its observed output combination has the effect of measuring the efficiency of each institution against its peers, where peers are defined by common outputs or output proportions. Small private institutions emphasizing academics are not evaluated against large public institutions with major sports programs. Each is evaluated against its peers in its common output niche among the observed outputs.

These efficiency scores are interpreted as measures of the best buys in higher education for a number of common "outputs" of interest. All successful institutions deliver a package of outputs and price that a sufficient number of students choose. Those "inefficient" institutions must provide some additional quality (output) or set of qualities (outputs) having value to students, but not captured in the data utilized here. Our analysis may aid consumers' evaluations of institutions by highlighting the premium charged by each institution for its unique output set as well as providing insight for policy makers on the relative efficiency of institutions in providing a minimal set of outputs.

3. Data and Variables

The primary source of the data for the empirical analysis is the U.S. Department of Education's National Center for Education Statistics (NCES) which conducts an annual survey of all institutions of higher education in the U.S. as part of the Integrated Post-Secondary Education Data System or IPEDS. The survey collects data from about 9,900 institutions across all of higher education: baccalaureate or higher degree granting, two-year, and less-than-two-year schools from the public, private not-for-profit, and for-profit sectors. In the current survey there are up to nine separate instruments containing hundreds of potential variables for an individual institution. [2]

Output measures are aspects of the "quality" of the institution and quality in higher education receives a great deal of attention both in the popular press and in academic literature. For the purpose at hand we assume that institutions select as outputs

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[2] IPEDS was created in 1986 and is accessible through the NCES Web site (http://nces.ed.gov/) for the years 1996 to the present. Earlier years are archived at the University of Michigan (http://webapp.icpsr.umich.edu/cocoon/IAED-SERIES/00102.xml). The predecessor to IPEDS was Higher Education General Information Survey or HEGIS which dates to 1967 with limited data back to 1965. These data are also archived at the International Archive of Education Data at the University of Michigan (http://webapp.icpsr.umich.edu/cocoon/IAED-SERIES/00030.xml). Some, though not all, of these data can be downloaded from the Michigan Web site.

quality attributes that best meet their mission as perceived by the administration and governing body. In the economics literature quality is often measured by peer quality, such as the SAT score (Mayer-Foukles 2002; McCormick and Tinsley 1987), or a college ranking scheme such as the *U.S. News & World Report* "America's Best Colleges" (Buss *et al.* 2004) or by inputs such as expenditures per student or faculty salaries or student evaluations of faculty (Brown 2001) . Black and Smith (2004) develop a composite measure consisting of average faculty salary, the average SAT score, and the average freshman retention rate for use in applying matching techniques to examine the relationship between college quality and wages.[3]

An interesting and long standing debate among academics of all disciplines concerns the role of athletics on campus. McCormack and Tinsley (1987) argue that athletics and academics are complementary. They posit that athletic success improves academic quality by attracting applicants which, in turn, permits colleges and universities to be more selective in their admissions. Empirically, they found that success in athletics was associated with an increase in the SAT scores of entering freshmen.

In order to take advantage of the strength of DEA and to capture as many characteristics of broad dimensions of higher education in the United States we choose nine output measures. The first is the SAT score for the 25th percentile of entering

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[3] On the issue of multidimensional assessments of quality, as determined by potential students. See Ehrenberg, R.G. (2002b). *Tuition Rising: Why College Costs so Much*. Cambridge: Harvard University Press.

> Indeed, once one realizes that different students may value the characteristics of universities differently, the notion that one can come up with a single number that summarizes the overall ranking of an academic institution seems quite silly… (p. 53)

freshmen in the fall 2000 as a measure of student peer quality. The second is a measure of student amenities, dormitory capacity or rooms per full-time-equivalent (fte). Endowment per fte is chosen to measure the financial success and loyalty of alumni. Athletic expenditure per fte is a measure of the quality of athletic programs at the school. The value of buildings per fte is a measure of the quality of campus facilities. Instructional expenditures per fte are a measure of faculty quality, class size, and the like. The Carnegie Level is a measure of the breadth of the institution's mission ranging from level one (1) for baccalaureate programs to level six (6) for doctoral/ research institutions. The percentage of the student body made up of African Americans is a measure of the racial diversity of the institution. Finally, religious affiliation is another measure of the mission of the institution.

Data were selected for 1,188 four-year, public and private institutions for the academic year 2000-01, the latest year for which complete data were available from the NCES on-line when the project began. More recent data are available for some surveys but not from the important Finance file. Net prices are calculated as the published tuition, fees, room and board less the per student average state and institutional financial aid.

In addition to the IPEDS data, SAT scores for the 25th percentile of entering freshmen for 2003 were collected from the *U.S. New & World Report Best Colleges in America* for 2003.[4] Athletic expenditures were collected from data submitted by

[4] The implicit assumption is, of course, that there were no substantive changes in relative entrance scores between the fall of 2000 and fall 2003.

universities to the U. S. Department of Education pursuant to the Equity in Athletics Disclosure Act (EADA) and available online at http://ope.ed.gov/athletics/index.asp.

Simple statistics and descriptions for each variable used in the DEA analysis are shown in Table 1.

4. DEA model and interpretation

Data Envelopment Analysis (DEA) is a technique especially well-suited for assessing efficiency in cases with multiple outputs or inputs. We begin by standardizing the input and each output to a mean of 100 and a standard deviation of 15. Our outputs are the nine variables described in Table 1, and our single input is net price per full-time-equivalent (PRI). Equations 6a and 6b formally present the DEA model. In our case, there are 1,188 higher education institutions, denoted by subscript *i*. The production process of the *i*th institutions is given by one input x_i and nine outputs y_{ri} (r = 1,…,9). The following linear programming problem solves for weights on the individual outputs (u_r), in order to assess the DEA efficiency of the *k*th institution.

$$\text{Maximize}\,\theta_k = \frac{\sum_r u_r y_{rk}}{x_k} \tag{6a}$$

$$\frac{\sum_r u_r y_{ri}}{x_i} \leq 1, \forall i \tag{6b}$$

$$u_r \geq 0, \ \forall r$$

The program selects weights to make the ratio of outputs to inputs for all institutions less than or equal to one; but it selects those weights such that the output-to-input ratio θ_k for *one particular institution* (institution *k*, in the objective function) is as high as possible. If the ratio θ_k for institution k is less than one, then, with the same weights, one or more other institutions *must* equal one. Thus, these other institutions are more efficient, since—even with the most favorable weighting scheme—institution k is unable to produce a proportionate output for the inputs it uses.

The DEA results provide not only a measure of efficiency for each school, but—more importantly—a way of determining the *comparative advantage* for each school. For each institution k, the weights u_{rk} will be set highest for those outputs for which that institution is *relatively* well-endowed—that is, relative to all other schools, considering all outputs.

The efficiency measure itself is best interpreted not as a measure of efficiency, but as a measure of the premium that students are willing to pay to attend a school. A school with low efficiency presumably has some attributes to draw students that are not considered in our limited set of outputs.

5. DEA results

Table 2 presents summary statistics for the DEA efficiency measures θ_k and the output weights u_{rk}. Geographic coordinates were available for all but seven of the 1,188 schools, permitting the construction of maps, presented in figures 1-10, showing the values for θ_k and each u_{rk}. The values on the map are smoothed, using the local G* statistic (Getis and Ord 1992), weighting over the nearest 10 neighbors for each school.

The maps reveal that the DEA efficiency measures θ_k are spatially autocorrelated: low values cluster in the Northeast, while high values are especially prevalent in the Southeast. Compared to the efficiency measures θ_k, the output weights u_{rk} are much more scattered, although for each of these there appears to be significant regional clustering. This is consistent with previous findings of spatial competition among institutions (McMillen et al., 2007).

Table 3 examines clustering more rigorously, by using a common test for spatial autocorrelation, the Moran's I (Cliff and Ord 1981). The results confirm that all 10 variables (the efficiency measure θ_k and the output weights u_{rk}) are positively spatially autocorrelated, but that the efficiency measure θ_k exhibits the highest degree of spatial autocorrelation. This suggests that schools in geographical proximity to each other must lie fairly close to each other in efficiency—in their ability to deliver output per dollar spent—but that they can differ more in the particular type of output delivered. In other words, schools engage in product differentiation even when competing with other nearby institutions.

The top 50 and bottom 50 institutions ranked by efficiency score are listed in the Appendix. Efficiency scores (theta) range from 0.612 to 1.0. As expected, the institutions at the top of the list are general purpose universities with relatively reasonable prices. Many are public institutions in the southeastern U.S. The bottom of the list is dominated by high-priced institutions, many in expensive locations such as the northeastern U. S., but also with elite specialized programs. Pratt Institute, a highly respected school of art and design in New York City, is an example. A complete listing of institutions, efficiency scores and attribute weights is available from the authors on request.

This emphasizes the care with which the DEA scores should be interpreted and highlights some of the problems with attempts to evaluate the cost-effectiveness of higher education institutions. Our measure of "efficiency" is purposely biased toward general education institutions and against highly specialized institutions. Institutions located in high cost areas will also tend to fair poorly under this measure, other things equal. Having institutions in diverse locations and operating in diverse product "niches" is a virtue that should not be ignored. In many cases, the efficiency scores reflect this diversity rather than true variations in efficiency, but illuminate the price premium prospective students may pay for attending an institution with a specialized program or location.

6. Summary and conclusion

The efficacy of DEA analysis for evaluating the price-quality relationships offered by institutions of higher education in the United States is demonstrated here. DEA efficiency scores are calculated for 1,188 institutions for the 2000-2001 academic year. These scores are interpreted as indicators of the best buys in higher education for the outputs, or quality attributes, observed. Theory shows that these measures are also indicators of relative net average cost, comparing each institution to the best practice frontier, for the output quality bundle observed.

The resulting efficiency scores show significant geographical clustering, as do the individual output weights, with the best buys clustered in the southeastern states. This finding suggests competitive activity among relatively nearby schools. The output weights also cluster, but not in identical fashion to the efficiency scores. In turn, this indicates that schools pursue product differentiation as a competitive strategy within geographic clusters, each institution seeking a niche, or set of niches, that distinguishes it from other institutions.

The efficiency scores also suggest a means of defining peer institutions. DEA takes into account both quality characteristics and the net-price of attendance, summarizing similar combinations in a single measure. This measure takes into account trade-offs among quality characteristics and net-price (net average cost).

The efficiency scores also may be helpful both to prospective students and to policymakers. The scores suggest the institutions offering the best net-prices for the bundles of output qualities measured. The scores also indicate the price premium charged by institutions with low efficiency scores, highlighting the pricing of institution specific characteristics not measured here. This information could lead to better informed choices by prospective students. Similarly, the DEA scores may aid policymakers' attempts to measure the cost effectiveness of diverse institutions.

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Tables and Figures

Table 1: Descriptive Statistics for DEA input and outputs

Variable	Label	Maximum	Minimum	Mean	Std Dev
Input					
pri	annual net price	21918	170	8415.17	4330.65
Outputs					
SAT	SAT 25th pctle	1460	590	963	128
rcf	room capacity per fte	3.202	0.009	0.469	0.298
cap	endowment per fte	22197	0	1,062	1,531
ath	athletic expnd per fte	7654	0	928	909
bld	building value per fte	223078	0	32,228	22,634
ins	instructional expnd per fte	67010	943	7,164	5,079
crn	Carnegie level	6	1	3.4	1.4
pbl	percent fte black	99	0	11.2	19.7
rel	religious affiliation	1	0	0.447	0.497

Notes: The variables are all standardized, to a mean of 100 and a standard deviation of 15, prior to estimating in the DEA model.

Table 2: Summary DEA results

Variable	Label	Maximum	Minimum	Mean	Std Dev
θ_k		1.0000	0.6121	0.8377	0.0778
weights (u_{rk})					
SAT	SAT 25th pctle	0.9002	0.0000	0.1294	0.1287
ath	athletic expnd per fte	0.6317	0.0000	0.0595	0.1122
bld	building value per fte	0.4175	0.0000	0.0751	0.1096
cap	endowment per fte	0.2258	0.0000	0.0172	0.0360
crn	Carnegie level	0.7908	0.0000	0.1357	0.1819
ins	instructional expnd per fte	0.2451	0.0000	0.0453	0.0680
pbl	percent fte black	1.0000	0.0000	0.0474	0.0905
rcf	room capacity per fte	0.4500	0.0000	0.0306	0.0768
rel	religious affiliation	1.0000	0.0000	0.4598	0.2216

Notes: The weights are given as the percentage of the sum of weights for each school.

Table 3: Autocorrelation test results

Variable	description	Moran z-score	p-value
θ_k	DEA efficiency	31.817	0.0000
weights (u_{rk})			
SAT	SAT 25th pctle	4.681	0.0000
ath	athletic expnd per fte	2.569	0.0051
bld	building value per fte	3.716	0.0001
cap	endowment per fte	1.989	0.0233
crn	Carnegie level	4.073	0.0000
ins	instructional expnd per fte	6.135	0.0000
pbl	percent fte black	15.009	0.0000
rcf	room capacity per fte	7.746	0.0000
rel	religious affiliation	4.506	0.0000

Notes: n= 1,181. The weight matrix for the Moran's I test contains equal weights for the closest 10 neighbors, and zero otherwise.

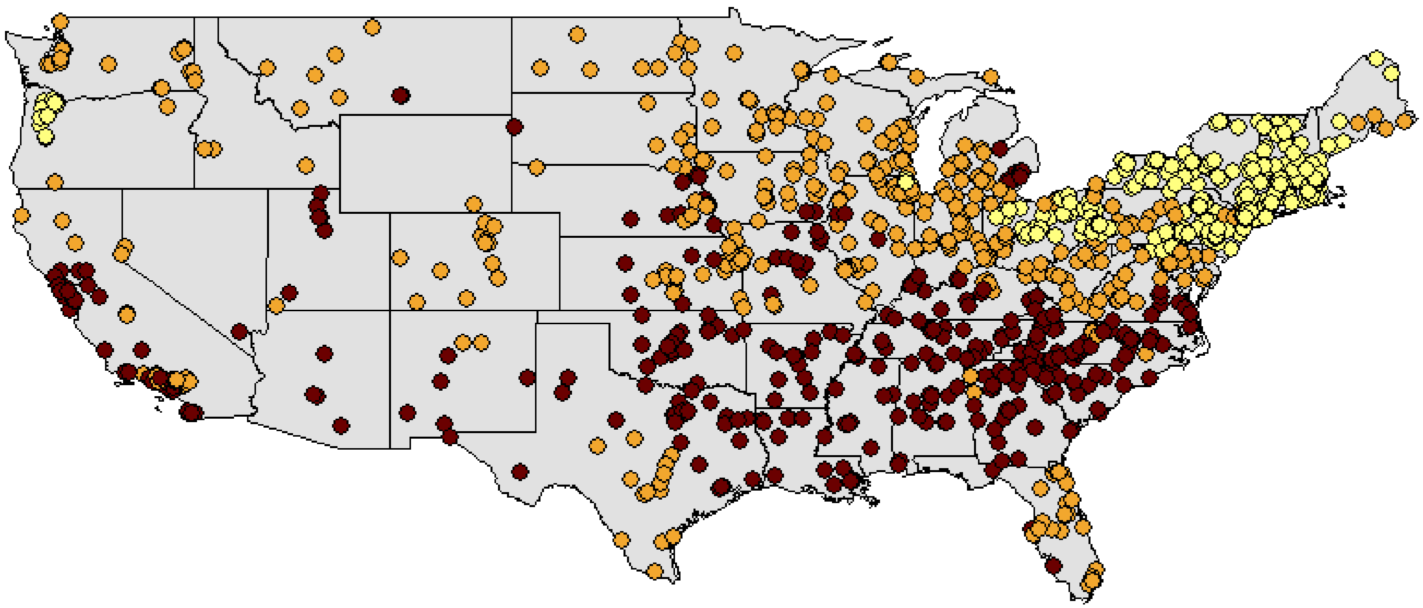

Figure 1: Smoothed DEA efficiency score θ_k (darker color represents higher values). (minimum value=-6.311238; breakpoint between the lowest tercile and middle tercile=-1.213834; breakpoint between middle tercile and upper tercile=1.141955; maximum value=4.808448)

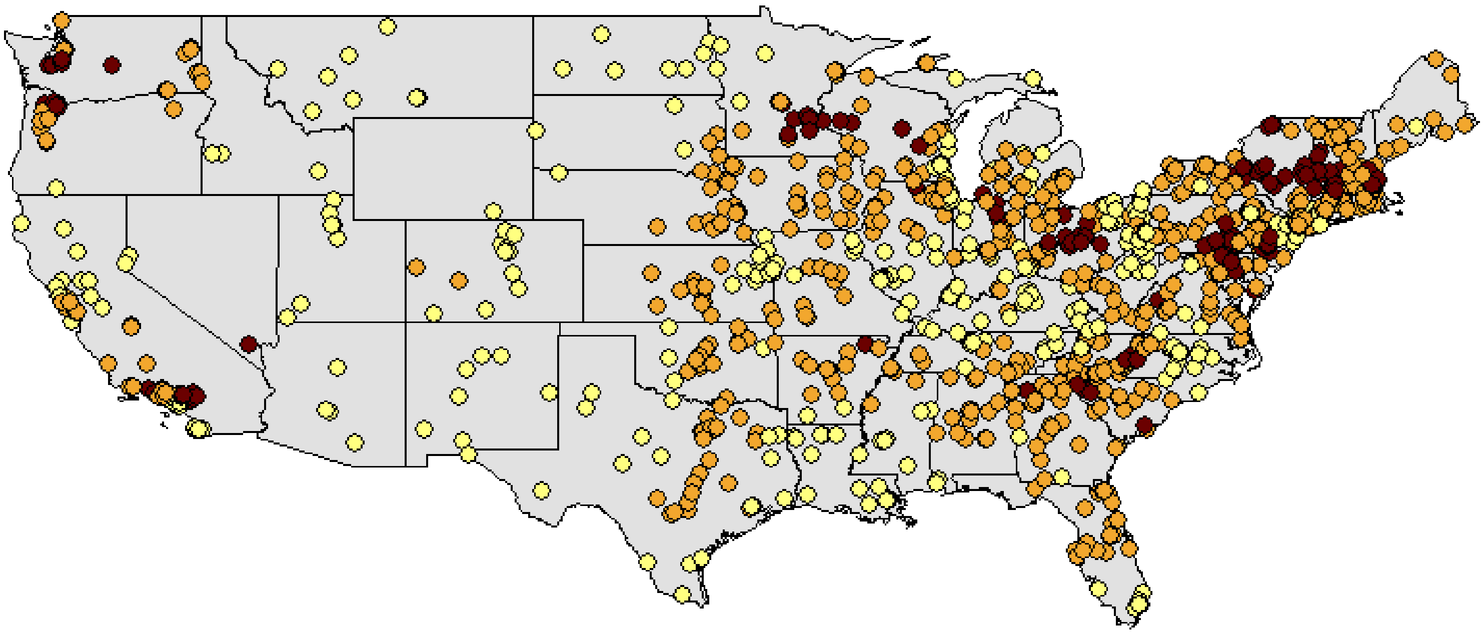

Figure 2: Smoothed weight for 25th percentile SAT score (darker color represents higher values). (minimum value=-2.962479; breakpoint between the lowest tercile and middle tercile=-0.473923; breakpoint between middle tercile and upper tercile=1.247656; maximum value=3.660702)

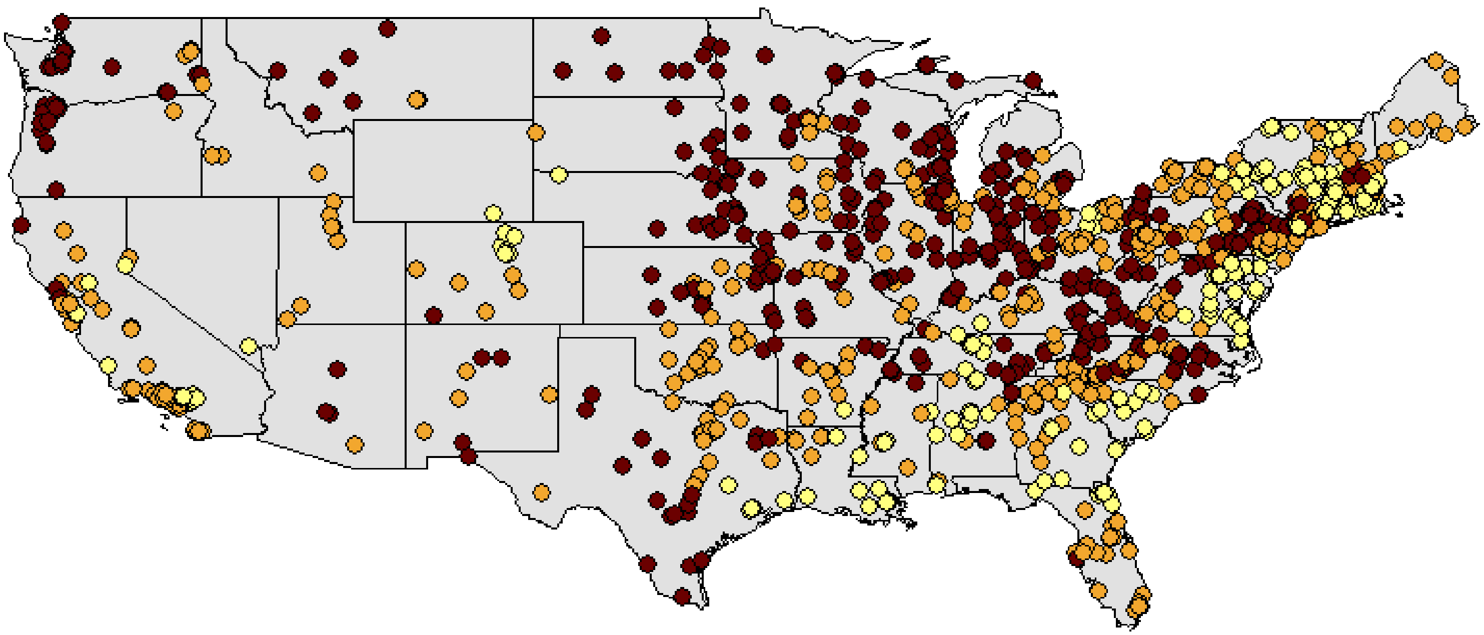

Figure 3: Smoothed weight for presence of religious affiliation (darker color represents higher values). (minimum value=-3.274182; breakpoint between the lowest tercile and middle tercile=-1.037617; breakpoint between middle tercile and upper tercile=0.486974; maximum value=2.855546)

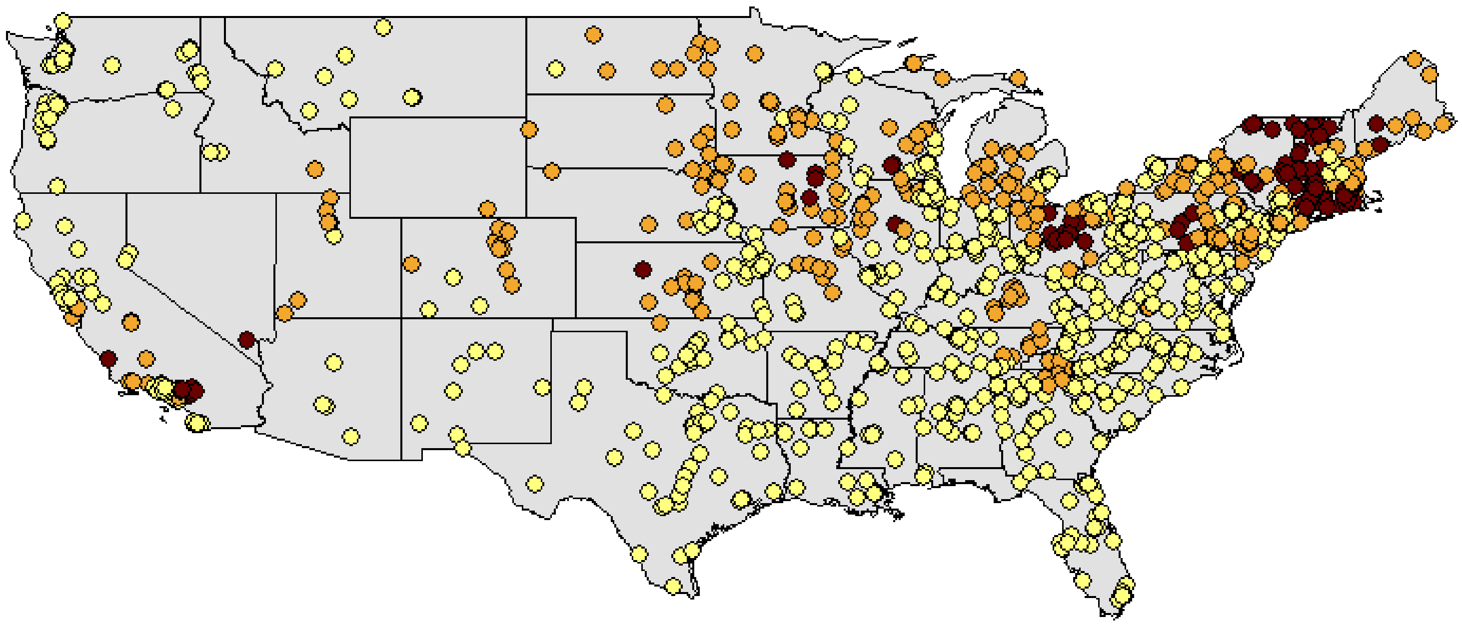

Figure 4: Smoothed weight for room capacity per FTE (darker color represents higher values). (minimum value=-1.330875; breakpoint between the lowest tercile and middle tercile=-0.033205; breakpoint between middle tercile and upper tercile=2.036789; maximum value=6.110163)

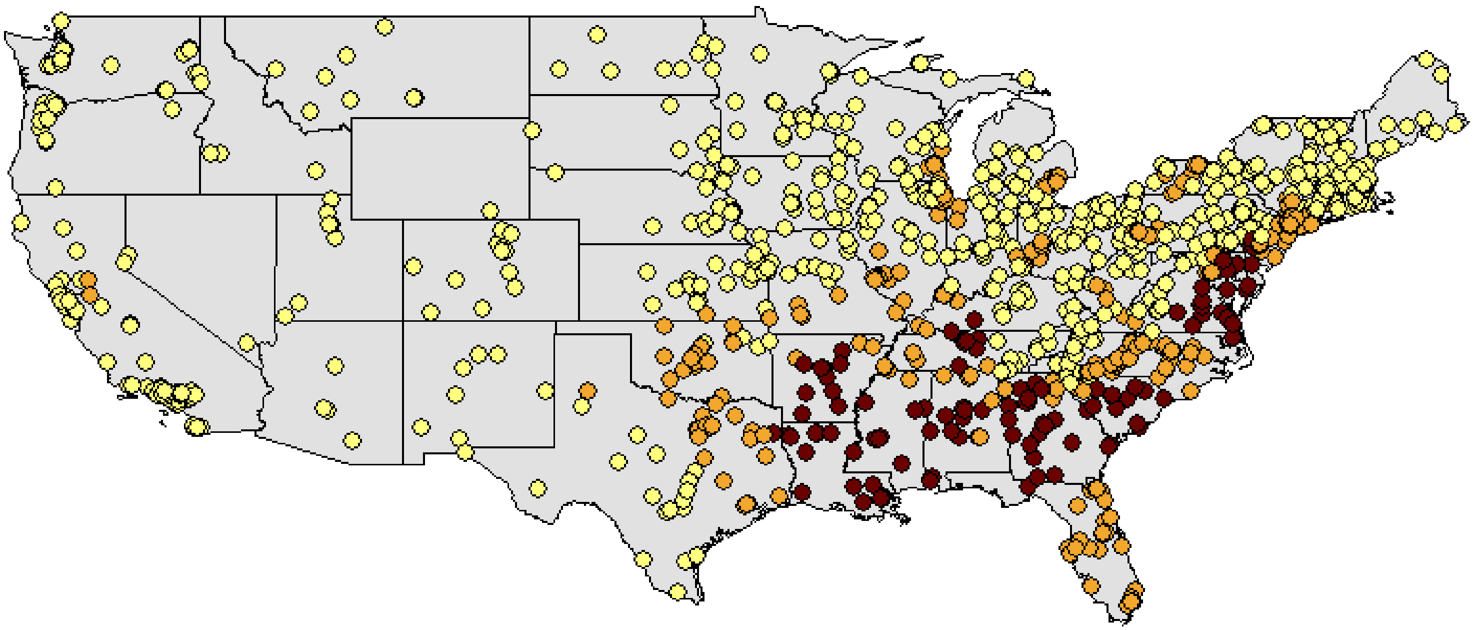

Figure 5: Smoothed weight for percent FTE African-American (darker color represents higher values). (minimum value=-1.743296; breakpoint between the lowest tercile and middle tercile=-0.216155; breakpoint between middle tercile and upper tercile=2.014592; maximum value=7.673673)

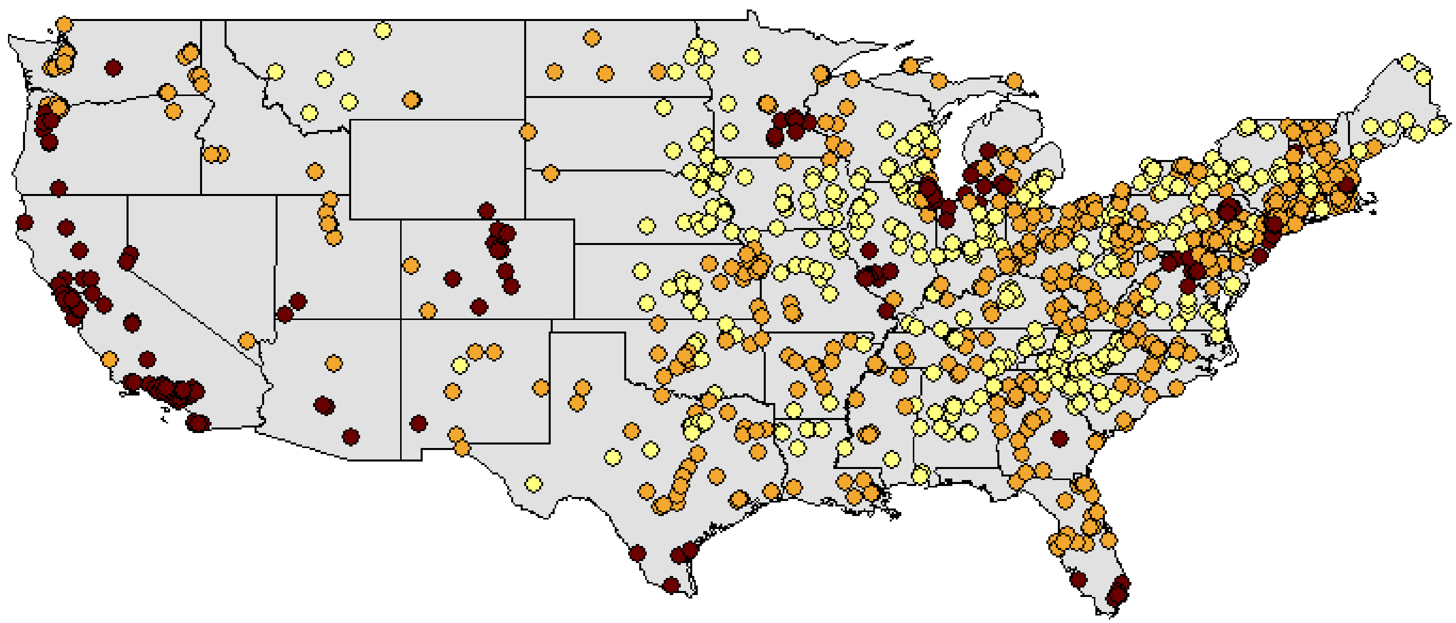

Figure 6: Smoothed weight for instructional expenditures per FTE (darker color represents higher values). (minimum value=-2.220902; breakpoint between the lowest tercile and middle tercile= -0.540701; breakpoint between middle tercile and upper tercile= 1.166396; maximum value=4.514036)

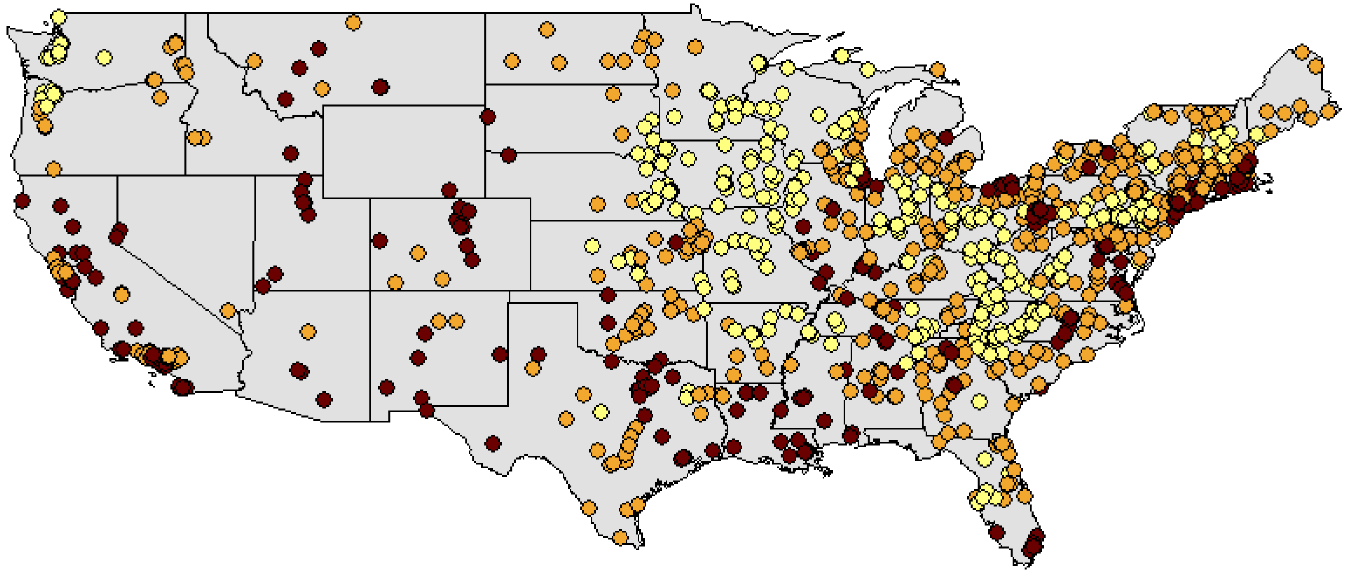

Figure 7: Smoothed weight for Carnegie classification (darker color represents higher values). (minimum value=-2.395318; breakpoint between the lowest tercile and middle tercile=-0.684188; breakpoint between middle tercile and upper tercile=0.829590; maximum value=3.281723)

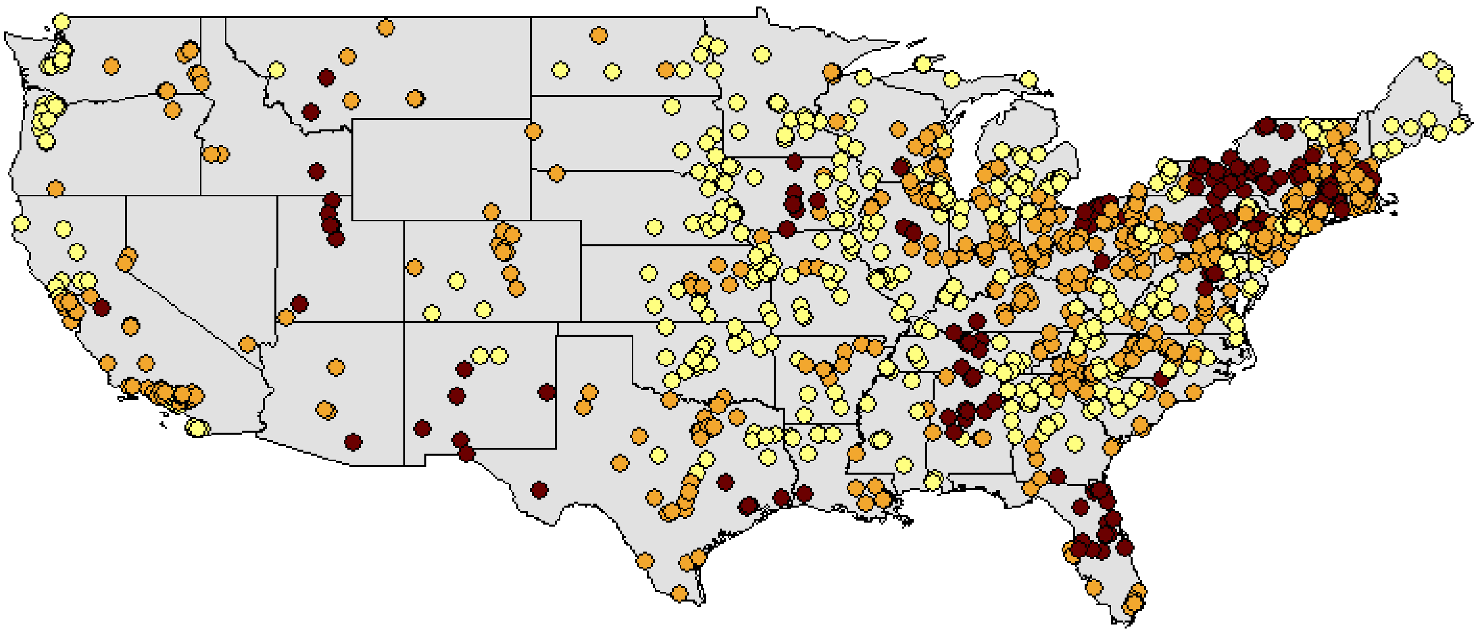

Figure 8: Smoothed weight for value of endowment per FTE (darker color represents higher values). (minimum value=-1.591158; breakpoint between the lowest tercile and middle tercile=-0.442027; breakpoint between middle tercile and upper tercile=1.12323; maximum value=4.64404)

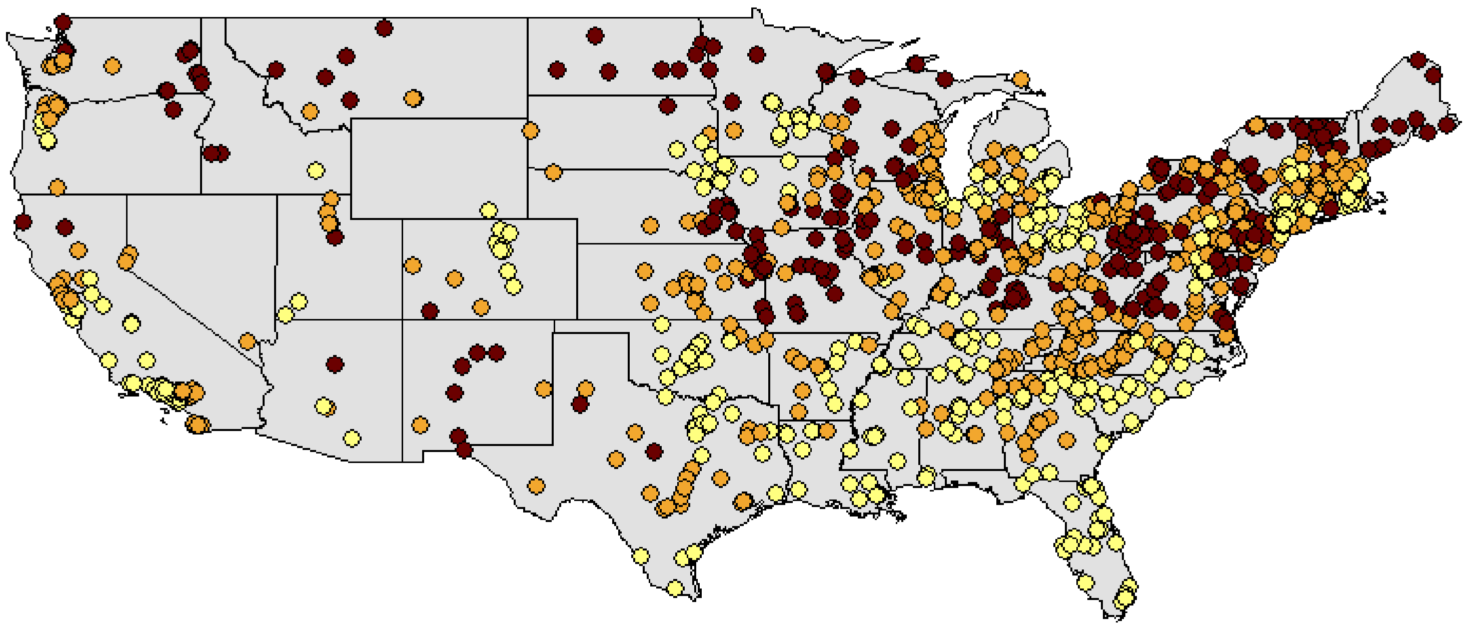

Figure 9: Smoothed weight for value of buildings per FTE (darker color represents higher values). (minimum value=-2.289728; breakpoint between the lowest tercile and middle tercile=-0.636697; breakpoint between middle tercile and upper tercile=0.770784; maximum value=3.286926)

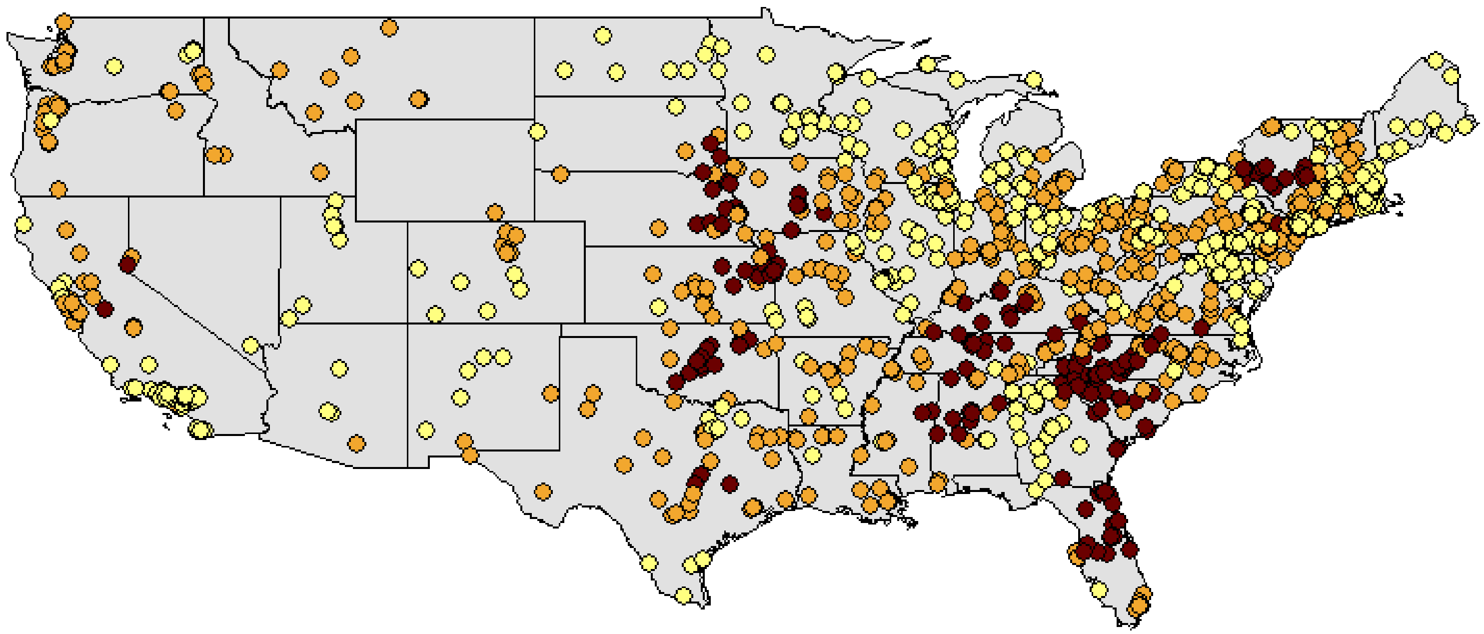

Figure 10: Smoothed weight for athletic expenditures per FTE (darker color represents higher values). (minimum value=-1.770016; breakpoint between the lowest tercile and middle tercile=-0.340975; breakpoint between middle tercile and upper tercile=1.160583; maximum value=4.990930)

APPENDIX:
Top 50 and Bottom 50 Ranked Institutions by Efficiency Score

Rank	School Name	State	Score
1	UNIVERSITY OF ALABAMA AT BIRMINGHAM	AL	1.00000
2	ALABAMA STATE UNIVERSITY	AL	1.00000
3	TALLADEGA COLLEGE	AL	1.00000
4	HENDRIX COLLEGE	AR	1.00000
5	PHILANDER SMITH COLLEGE	AR	1.00000
6	CALIFORNIA BAPTIST UNIVERSITY	CA	1.00000
7	CALIFORNIA INSTITUTE OF TECHNOLOGY	CA	1.00000
8	THOMAS AQUINAS COLLEGE	CA	1.00000
9	DELAWARE STATE UNIVERSITY	DE	1.00000
10	FLORIDA AGRICULTURAL AND MECHANICAL UNIVERSITY	FL	1.00000
11	UNIVERSITY OF GEORGIA	GA	1.00000
12	PAINE COLLEGE	GA	1.00000
13	WILLIAM TYNDALE COLLEGE	MI	1.00000
14	ALCORN STATE UNIVERSITY	MS	1.00000
15	JACKSON STATE UNIVERSITY	MS	1.00000
16	DANA COLLEGE	NE	1.00000
17	NEW MEXICO INSTITUTE OF MINING AND TECHNOLOGY	NM	1.00000
18	UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL	NC	1.00000
19	CENTRAL STATE UNIVERSITY	OH	1.00000
20	UNIVERSITY OF OKLAHOMA NORMAN CAMPUS	OK	1.00000
21	WOFFORD COLLEGE	SC	1.00000
22	BELMONT UNIVERSITY	TN	1.00000
23	THE UNIVERSITY OF TENNESSEE	TN	1.00000
24	COLLEGE OF WILLIAM AND MARY	VA	1.00000
25	VIRGINIA MILITARY INSTITUTE	VA	1.00000
26	BRIGHAM YOUNG UNIVERSITY HAWAII CAMPUS	HI	0.99838
27	CAMPBELLSVILLE UNIVERSITY	KY	0.99831
28	UNIVERSITY OF KENTUCKY	KY	0.99806
29	FORT VALLEY STATE UNIVERSITY	GA	0.99732
30	HOWARD UNIVERSITY	DC	0.99468
31	GALLAUDET UNIVERSITY	DC	0.99179
32	UNIVERSITY OF WYOMING	WY	0.98961
33	STANFORD UNIVERSITY	CA	0.98752
34	UNIVERSITY OF LOUISVILLE	KY	0.98614
35	UNIVERSITY OF IOWA	IA	0.98556
36	UNIVERSITY OF MISSOURI COLUMBIA	MO	0.98281
37	UNIVERSITY OF FLORIDA	FL	0.98281
38	NORTH CAROLINA CENTRAL UNIVERSITY	NC	0.98276
39	ARKANSAS BAPTIST COLLEGE	AR	0.98255
40	UNIVERSITY OF ALABAMA	AL	0.98191
41	FLORIDA MEMORIAL COLLEGE	FL	0.97967
42	LYON COLLEGE	AR	0.97752
43	CHEYNEY UNIVERSITY OF PENNSYLVANIA	PA	0.97647
44	BRIGHAM YOUNG UNIVERSITY	UT	0.97586
45	UNIVERSITY OF MISSOURI ROLLA	MO	0.97576
46	VIRGINIA COMMONWEALTH UNIVERSITY	VA	0.97532
47	JARVIS CHRISTIAN COLLEGE	TX	0.97385
48	ELIZABETH CITY STATE UNIVERSITY	NC	0.97276
49	CENTENARY COLLEGE OF LOUISIANA	LA	0.97245
50	WAYLAND BAPTIST UNIVERSITY	TX	0.97228

Rank	School Name	State	Score
1138	WORCESTER POLYTECHNIC INSTITUTE	MA	0.68670
1139	HAWAII PACIFIC UNIVERSITY	HI	0.68635
1140	CLARK UNIVERSITY	MA	0.68625
1141	CHAMPLAIN COLLEGE	VT	0.68615
1142	LAKE ERIE COLLEGE	OH	0.68514
1143	WHEELOCK COLLEGE	MA	0.68487
1144	WILKES UNIVERSITY	PA	0.68474
1145	FRANKLIN AND MARSHALL COLLEGE	PA	0.68285
1146	DEAN COLLEGE	MA	0.68226
1147	COLLEGE OF MOUNT SAINT VINCENT	NY	0.68178
1148	ELMIRA COLLEGE	NY	0.68157
1149	FRANKLIN PIERCE COLLEGE	NH	0.68038
1150	HARTWICK COLLEGE	NY	0.67918
1151	QUINNIPIAC UNIVERSITY	CO	0.67693
1152	PAUL SMITHS COLLEGE OF ARTS AND SCIENCE	NY	0.67586
1153	MITCHELL COLLEGE	CO	0.67516
1154	SAINT THOMAS AQUINAS COLLEGE	NY	0.67515
1155	WHEATON COLLEGE	MA	0.67439
1156	WESTERN MARYLAND COLLEGE	MD	0.67347
1157	NEWBURY COLLEGE BROOKLINE	MA	0.67340
1158	DELAWARE VALLEY COLLEGE	PA	0.67321
1159	NEW ENGLAND COLLEGE	NH	0.67200
1160	SIERRA NEVADA COLLEGE	NV	0.67195
1161	LAKE FOREST COLLEGE	IL	0.67031
1162	MARYMOUNT COLLEGE	NY	0.66939
1163	THE SAGE COLLEGES TROY CAMPUS	NY	0.66791
1164	BALTIMORE INTERNATIONAL COLLEGE	MD	0.66660
1165	FISHER COLLEGE	MA	0.66459
1166	GEORGE WASHINGTON UNIVERSITY	DC	0.66353
1167	NEW YORK UNIVERSITY	NY	0.66206
1168	WESTERN NEW ENGLAND COLLEGE	MA	0.66121
1169	ENDICOTT COLLEGE	MA	0.65713
1170	ROGER WILLIAMS UNIVERSITY	RI	0.65619
1171	UNIVERSITY OF PUGET SOUND	WA	0.65568
1172	COLBY SAWYER COLLEGE	NH	0.65549
1173	MANHATTANVILLE COLLEGE	NY	0.65395
1174	SIMMONS COLLEGE	MA	0.65276
1175	PRATT INSTITUTE MAIN	NY	0.65077
1176	MARYMOUNT MANHATTAN COLLEGE	NY	0.65067
1177	SIMONS ROCK COLLEGE OF BARD	MA	0.64794
1178	CURRY COLLEGE	MA	0.64545
1179	HIRAM COLLEGE	OH	0.64290
1180	EMERSON COLLEGE	MA	0.63540
1181	MEDAILLE COLLEGE	NY	0.63443
1182	WHITMAN COLLEGE	WA	0.63367
1183	GODDARD COLLEGE	VT	0.63252
1184	JOHNSON AND WALES UNIVERSITY	RI	0.62623
1185	MOUNT IDA COLLEGE	MA	0.62301
1186	SUFFOLK UNIVERSITY	MA	0.62272
1187	DANIEL WEBSTER COLLEGE	NH	0.62218
1188	NEW SCHOOL UNIVERSITY	NY	0.61214