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Benchmarking public school performance by unionized status

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Abstract

Purpose – There are elevated debates on the role of teacher unions on the effectiveness of education in the USA. The purpose of this paper is to examine if the unionization of education has an impact on the comparative performance of public education in the USA.

Design/methodology/approach – The authors classify states into two groups such as highly unionized states and less unionized states for comparing their performance differences. The analyses consist of two stages. First, the authors apply data envelopment analysis (DEA) to the key performance indicators of the groups. Next, the authors use statistical analysis for confirming the statistical significance of the performance differences that may exist between two groups.

Findings – The authors have confirmed the adverse impact of unionization on public education using DEA models and non-parametric rank-sum tests. However, the authors are cautious for generalizing the finding due to the limitations described in the research limitation section.

Research limitations/implications – The finding is limited within the selection of the variables and model specification and requires additional studies using different variables and models. The authors hope that the study motivates researchers to conduct further studies in this area.

Originality/value – Major contributions of the study include a novel approach for measuring the performance of primary and secondary schools at the state level by classifying and choosing less or highly unionized states and suggesting insights for improvements.

Keywords Performance measurement, Benchmarking, Data envelopment analysis

Paper type Research paper

Introduction

There are proponents and opponents of teacher unions, that is, collective bargaining agreements, in conjunction with the effectiveness of education in the USA. In some states, politicians see teacher unions as gatekeepers against changes and have passed hostile bills to eliminate or weaken the unions. Other states such as Colorado do not allow a teacher union with collective bargaining power. Teacher unions are still ongoing issues in states such as Wisconsin and Ohio. In fact, the literature has shown mixed results on the relationship between teacher unions and student achievement (Peltzman, 1993, 1996; Steelman *et al.*, 2000; Lindy, 2011; Lott and Kenny, 2013). This study will examine if the unionization of education has an impact on the comparative performance of public education in the USA.

Supporters of organized labor assert that unions benefit the educational system in many ways (Brunner and Squires, 2013; Goldstein, 2011). For example, unions protect educators from mandates set by inexperienced administrators and boards by giving them a collective voice to speak out about their interests. Teacher unions have begun

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supporting education reform to further promote advancement of students. Union representation can result in job security and fair compensation for teachers. In addition, union membership often includes liability insurance to protect teachers in the event of unfounded lawsuits.

Opponents of organized labor argue that outdated contracts protect teachers against unfair policies that are no longer practiced. Teacher unions have the potential to block education reform that is necessary to improve educational systems. Additionally, many opponents argue that merit pay and tenure enable underperforming teachers to remain in the classroom, resulting in a negative impact on student performance (Strunk, 2011; Smith, 2013).

The primary purpose of this study is to measure the comparative performance of schools at the state level in the USA by controlling teacher unions. We apply data envelopment analysis (DEA) and non-parametric rank-sum tests to the study. We include internal and external factors as the variables in the study and suggest improvements on the variables and managerial insights from our findings. A major contribution of this study is a novel approach for analysis, which considers teacher unions as the control factor by classifying states into two groups by the degree of collective bargaining status. The rest of this study consists of related studies, methodologies, data and variables, and results and discussion followed by a conclusion.

Related studies

Our literature review consists of two parts: a review of empirical studies on teacher unions and student performance and a review of DEA studies on teacher unions and student performance. We use student performance and school performance interchangeably. That is, we view student performance as school performance or productivity in this study. In fact, many studies have used student performance or achievement as school performance at various levels such as school districts, states, and countries as presented in the following literature review.

Empirical studies on teacher unions and student performance

There are various approaches for measuring the relationship between teacher unions and student performance in general: the strength of teacher unions and student achievement (Lott and Kenny, 2013), collective bargaining laws and student performance (Lindy, 2011), collective bargaining agreements and student performance (Strunk, 2011), teacher unionization and student performance (Kingdon and Teal, 2010; Hoxby, 1996), teacher unions and the probability of high school dropout (Zwerling and Thomason, 1994), and teacher unions and student achievement (Grimes and Register, 1990). Although they look similar, they differ on focusses, measures, and other dimensions. We review these articles in detail in the following paragraphs.

Lott and Kenny (2013) examined the relationship between teacher union strength and student achievement using 2005-2006 data. They measured union strength with union dues per teacher and union expenditures per student, which were independent variables in regression models. The dependent variable was students' math or reading scores in respective regression models. They found that union strength was negatively correlated with student achievement. Although they justified the use of union dues and expenditures for measuring union strength, they overlooked the level of teacher unionization in a state and teacher unions without collective bargaining power.

Lindy (2011) attempted to find reliable empirical evidence of the causal result of teacher bargaining on student achievement by arguing that existing studies had

promoted the debate between union supporters and critics rather than clarifying it. He analyzed panel data sets using regression models, which were collected from a New Mexico natural experiment. He employed scholastic aptitude test (SAT) scores, average freshman graduation rates, or expenditures per pupil as a dependent variable in each regression model along with socioeconomic independent variables. He found that mandatory bargaining laws caused an increase in students' SAT scores and a decrease in high school graduation rates. He concluded that teacher bargaining laws increased the performance of high-achieving students while decreasing the performance of poorly achieving students.

Strunk (2011) explored collective bargaining agreements and their relationship with district resource allocation and student performance in California using data collected in the 2005-2006 school year. She measured the strength of teacher unions by assessing the underlying latent restrictiveness of teacher union contracts. She included this variable along with socioeconomic variables for explaining school district expenditures or student achievement measured with standardized test scores in regression models. She found that districts with more restrictive collective bargaining agreements showed higher spending, and restrictive contracts were related to lower average student performance, which, however, were not associated with decreased achievement growth.

Kingdon and Teal (2010) investigated the relationship between teacher unionization, student achievement, and teachers' pay using a cross-sectional data from private schools in India. They used personal and socioeconomic variables along with teachers' union membership for explaining students' standardized test scores and teachers' pay. Using the results from series of ordinary least square regression models, they concluded that teachers' union membership reduced student achievement and increased costs in private schools in India.

Hoxby (1996) attempted to explain dropout rates using explanatory variables such as teacher salaries, student-teacher ratios, expenditures per pupil, unionization indicators, and demographic variables. Using panel data, she found that teacher unions might hinder competition among public schools, which could be interpreted into as increased inputs and decreased student performance (an output). Zwerling and Thomason (1994) also conducted a similar study using dropout rates and other socioeconomic variables and reached the identical conclusion. However, as Lindy (2011) pointed out, dropout rates could be the achievement measures of poorly performing students. Accordingly, the conclusion by Hoxby (1996) and Zwerling and Thomason (1994) should be limited to interpreting the relationship between teacher unions and the poorly performing students.

Grimes and Register (1990) measured the relationship between student performance on the Test of Economic Literacy and a dummy variable for teacher unions (1 for teachers in unionized districts and 0 for those in non-unionized districts) along with socioeconomic variables. In the series or blocks of regression analysis, they found that students in the unionized school districts showed a significantly higher level of achievement in economics. They concluded that teacher unions positively influenced teacher productivity of economic understanding.

According to Fenster (2009), collective bargaining agreements affected the way that schools were managed, from teacher salaries to class sizes to instructional time. He discussed the many studies that had been conducted to determine the impact that unions had on student achievement. The empirical evidence was mixed, with no consensus having been reached among the researchers. Instead of using DEA, this study evaluated all 50 states, plus the District of Columbia, using one-way analysis of variance

and multiple regression analysis. Variables were test scores for fourth and eighth grade in math, science, reading, and writing along with percentage of students eligible for the lunch program. When controlling for the socioeconomic differences, the results differed among subject areas. He concluded that there was a strong negative impact in the areas of math and reading, a negative but lesser impact on writing. Conversely, he found that there was a mixed, but more of a positive impact in the area of science.

DEA studies on teacher unions and student performance

Agasisti (2014) assessed spending efficiency on education for 20 European countries and found that these countries were more efficient than Organization for Economic Co-operation and Development (OECD) countries. He assessed the spending efficiency of the countries in two stages. In the first stage, he chose the mathematics scores of the OECD-Program for International Student Assessment (PISA) tests administered in 2006 through 2009 as an output variable and student-teacher ratios and expenditures per student as input variables. He then computed the efficiency scores of the countries for their education spending using DEA. In the second stage, he applied regression analysis to explain the efficiency scores computed with DEA using a set of independent variables such as gross domestic production per capita, average teachers' salary, students' internet use, public education spending, and instruction time. He also measured efficiency changes over time using Malmquist Index. He found that teachers' salaries and students' internet use were positively related to educational performance.

Johnson and Ruggiero (2014) asserted that comparative efficiency differences and performance changes in public education systems could be heavily influenced by non-discretionary environmental factors. By reviewing the related studies on education performance, they found that school districts showed favorable results when students' economic status was better. They tested this proposition using data from 604 school districts in Ohio and Malmquist Index for identifying efficiency, technological, and environmental changes over time. They concluded that the productivity changes of poorly performing school districts were affected by changes in environment harshness, and that those of highly performing school districts were influenced by technical progress.

Blackburn *et al.* (2014) examined the efficiency of Australian primary and secondary schools using DEA. By controlling schools' socioeconomic environments, which could be different among the schools, they could measure unbiased efficiency. In fact, comparing schools with unfavorable socioeconomic environments to those with favorable socioeconomic environments could result in biased results. DEA models with hierarchical categories were used for grouping similar schools and analyzing their efficiencies within a group and across groups. They discovered that the schools were weakly efficient and that the quantile of schools with the most favorable environment gained efficiency. They concluded that efficiency gains were associated with increasing enrollment.

Harrison and Rouse (2014), similar to the study by Blackburn *et al.* (2014), chose a categorical DEA model to handle the different socioeconomic environments of schools in New Zealand for analyzing their efficiency. To consider the fact that the public and private schools in New Zealand had to compete for students due to the elimination of school zones, they used regression analysis for exploring the relationship between DEA efficiency scores and different levels of competition and found that mean school performance was higher for the schools located in areas of higher competition.

Agasisti (2013) computed the efficiency scores of sample Italian schools using OECD-PISA 2006 data at a school level. He employed a two-stage analysis using DEA and Tobit regression. He found that an explanatory variable related to competition was statistically

significant for explaining student achievement. He concluded that increasing the number of schools competing with each other could boost school performance.

Cordero-Ferrera *et al.* (2008) recognized the complexity of evaluating the efficiency of the education system. They found that measuring the production output of school districts was difficult. Additionally, there were many exogenous factors that could impact production results, such as socioeconomic characteristics, student ability levels, and peer group effects. To address these issues, they applied a four-stage DEA model to a group of 80 Spanish high schools. In the initial stage, efficiency was calculated without including the non-discretionary inputs. The efficiency scores were subsequently adjusted to account for the non-controllable variables. To measure output, they constructed two measures from the University Entrance Exam that students had to take upon graduation: the average mark of pupils passing the exam and the percentage of pupils who passed the exam. They chose the attributes of 11 variables to identify four non-discretionary input variables, which represented multiple characteristics of a student's environment. Finally, they included two discretionary input variables: number of teachers per 100 pupils and total cost per student. By comparing the multi-stage model to the initial DEA model, they were able to draw several conclusions. First, more units benefited from the non-discretional inputs than those that were negatively impacted. Second, the number of efficient districts increased. Finally, initial scores changed significantly with the addition of the non-controllable inputs. They concluded that it was essential to include the effect of non-discretionary inputs when evaluating the efficiency of educational systems.

Ruggiero (2007) used DEA to analyze 607 Ohio school districts based on accountability and efficiency, rather than on equity. He divided the 607 districts into five groups according to the number of standards met out of 27 indicators. Ratings were indicated after each of the five categories: academic emergency (less than eight standards met), academic watch (8-12 standards met), continuous improvement (13-20 standards), effective (21-25 standards met), and excellent (at least 26 out of 27 standards met). The DEA model included two input variables: median district income as a socioeconomic indicator and expenditures per pupil. Output variables consisted of the percentage of students passing math and reading tests in both fourth and sixth grades and the graduation rate. He discovered that Ohio's classification system, which was based on the previously listed standards, was not a good indicator of district efficiency. For example, one district, classified as academic emergency, was actually found to be 100 percent efficient. This was possible because the district was providing the maximum output given the available inputs. Furthermore, given an additional $335 per pupil, this district would be capable of achieving adequacy standards. Conversely, another district, rated as excellent, was identified as 75 percent efficient. This particular district had a very favorable cost environment and could achieve the same results by spending $2,000 less per pupil. Ultimately, he concluded that Ohio school districts were terribly inefficient. Instead of additional funding, districts should be encouraged to be more efficient by being held more accountable.

Chakraborty *et al.* (2001) analyzed 40 Utah school districts using DEA, a non-parametric method, and the stochastic frontier method, a parametric method. Inputs were managerially controlled factors such as student teacher ratio, the proportion of teachers with advanced degrees, and the percentage of teachers with experience over 15 years, and environmental factors such as socioeconomic status, education level of local population, and assessed real property value per student. The single output was a composite of reading, writing, and math skills of 11th graders. They used a two-stage approach, first using only discretionary inputs, and then adding

the non-discretionary variables. They concluded that socioeconomic and environmental variables had a strong impact on student achievement.

Bates (1997) reviewed common methods for analyzing the efficiency of public education, including simple measures of average scores, proportions of pupils attaining a given standard to those incorporating previous levels of attainment, and those concerned with efficiency, which measured inputs and outputs. He discussed how to choose correct DEA models and how to use categorical variables, such as economic status of parents and rural vs urban impacts on efficiency. He cautioned researchers on dealing with categorical variables, including the number of factors to consider, the treatment of returns-to-scale, and the treatment of individuals not possessing the measured characteristic. He concluded that given the inherent problems to assessing educational efficiency, the best use of DEA assumed a constant return to scale. In addition, inputs should not be taken at face value but should be evaluated and adjusted. These adjustments required the use of further statistical analysis when using categorical input variables in the DEA analysis.

Chalos (1997) used DEA to evaluate 207 elementary school districts in the state of Illinois for the academic year 1989. He selected pupil attendance rates, percentage of teachers with a master's degree, percentage of non-low income, percentage of non-minority, and operating expenditures as the input variables. Illinois Goal Assessment Program math and verbal test scores for grade levels 6 and 8 were used to measure student performance. Taking care to account for controllable vs uncontrollable variables, he found that DEA results supported three hypotheses on budgets. The results of this study indicated that efficient districts spent significantly less per pupil on average than inefficient districts. Additionally, the implication was that information available through DEA analyses could be used to improve the efficient allocation of scarce resources. Finally, it should be noted that socioeconomic factors significantly influence performance and had be controlled for when measuring school district efficiency.

Bessent *et al.* (1982) measured the performance of 167 schools in the Houston Independent School District using DEA and standardized test scores such as the Iowa Test of Basic Skills. They selected the mean of the third grade and sixth grade composite scores as outputs in their analysis. They included 12 inputs, including socioeconomic factors like percent non-minority enrollment, percent of students paying full lunch price, and attendance rates, along with managerially controlled inputs such as number of professionals per 100 students, percent of teachers with master's degrees, percent of teachers with experience more than three years, and expenditures per student, among others. They found that 46.7 percent of the schools were inefficient. They identified resource utilization opportunities and proposed managerial insights that could be implemented by principals.

Overall, we have reviewed two streams of studies on student or school performance. One stream includes empirical studies with regression analysis, which focus on the impact of teacher unions on student achievement, and the other stream comprises efficiency studies with DEA, which emphasize school or student performance with multiple inputs and outputs. At the time of this study, although a handful of empirical studies have addressed it, we fail to find a DEA study that measures the impact of teacher unions on school or student achievement. Thus, our study fills this void and contributes to the body of knowledge in this area.

Methodology

We employ DEA for measuring the comparative efficiencies in public education of a group of highly unionized states to a group of less unionized states. DEA is a special

application of linear programming (LP) based on the frontier methodology of Farrell (1957). Since Farrell (1957), major breakthroughs for developing DEA were achieved by Charnes *et al.* (1978) and by Banker *et al.* (1984). DEA is a useful approach for measuring relative efficiency among similar organizations or objects. An entity that is an object to be measured for efficiency is called a decision-making unit (DMU). Because DEA can identify relatively efficient DMUs among a group of given DMUs, it is a promising tool for comparative analysis or benchmarking.

To explore the mathematical property of a basic DEA model, let E_0 be an efficiency score for the base DMU 0, then:

$$\text{Maximize } E_0 = \frac{\left\{\sum_{r=1}^{R} u_{r0} y_{r0}\right\}}{\left\{\sum_{i=1}^{I} v_{i0} x_{i0}\right\}} \tag{1}$$

subject to:

$$\frac{\left\{\sum_{r=1}^{R} u_{r0} y_{rk}\right\}}{\left\{\sum_{i=1}^{I} v_{i0} x_{ik}\right\}} \leqslant 1 \text{ for all } k \tag{2}$$

$$u_{r0},\ v_{i0} \geqslant \delta \text{ for all } r,\ i, \tag{3}$$

where y_{rk} is the observed quantity of output r generated by unit $k = 1, 2, \ldots, N$; x_{ik} is the observed quantity of input i consumed by unit $k = 1, 2, \ldots, N$; u_{r0} is the weight to be computed given to output r by the base unit 0; v_{i0} is the weight to be computed given to input i by the base unit 0; and δ is a very small positive number.

The fractional programming model can be converted to a common LP model without much difficulty. First, move the numerator in Equation (1) to the side constraint and set it equal to unity. Next, convert Equation (2) to a non-linear form by multiplying its numerator on both sides. The above model utilizes a constant returns-to-scale so that all observed production combinations can be scaled up or down proportionally (Charnes *et al.*, 1978: a CCR model). However, when we use a piecewise LP, we can model a non-proportional returns-to-scale such as an increasing, decreasing, or variable-returns-to-scale (Banker *et al.*, 1984: a BCC model). Depending on returns-to-scales and/or various modeling approaches, different types of DEA models are available.

Sherman and Ladino (1995) list the properties of DEA as follows:

- detects the best practice DMU that uses the least resources to provide its products or services at or above the quality standard of other DMUs;
- compares the less efficient DMUs to the best practice DMU;
- finds the amount of excess resources used by each of the less efficient DMUs; and
- reveals the amount of excess capacity or ability to increase outputs for less efficient DMUs, without requiring added resources.

In this study, we use bilateral BCC, CCR, and slack-based measure of efficiency (SBM) models (Cooper *et al.*, 2007, pp. 236-238) to compare two groups of states (highly unionized and less unionized). A BCC model employs variable returns-to-scale and measures pure technical efficiency (PTE). Meanwhile, a CCR model uses constant

returns-to-scale and assesses technical efficiency (TE). The relationship between these two models is: TE = PTE × SE, where SE represents scale efficiency. According to Cooper *et al.* (2007, p. 153), PTE means efficiency on operations, and SE denotes efficiency on operating conditions. An SBM model measures mix efficiency (MIX) along with TE. MIX shows efficiency on the mix of inputs or outputs. Thus, a SBM score can be "MIX × PTE × SE." By utilizing this relationship, we can identify sources of inefficiency when we measure the efficiency of DMUs. Based on the results of the DEA models, we test three hypotheses on the performance of education systems using non-parametric rank-sum statistics. After testing the hypotheses, we conduct post-analysis using an output-oriented SBM model for examining inefficiency, which will assist mangers in identifying the output variables that need improvement.

Data and variables

For this study, it was necessary to identify the degree of union representation by state. The relevant data were available through the Institute of Education Sciences (IES) and the National Center for Education Statistics (NCES), divisions of the US Department of Education (US Department of Education: National Center for Education Statistics, 2009a, b, c). A Schools and Staffing Survey provides the percentage of public school districts having specific agreements with teachers' associations or unions (see the Appendix). This means the teachers' unions and appropriate professional organizations have the power to negotiate on behalf of their membership; generally, such items include salaries, benefits, and conditions of employment. States were then categorized as highly unionized and less unionized states. Those states having collective bargaining scores greater than 87 percent were identified as "highly unionized," while those with scores less than 2 percent were identified as "less unionized." This provided us with two groups of 11 states each (see the Appendix), which are compared using appropriate DEA models. Following is a discussion of the variables that were selected to evaluate the efficiency of these 22 states and to compare the "highly unionized" group to the "less unionized" group. Our data were collected at a state level. Accordingly, our study did not include data for individual schools or school districts.

This study utilizes three input variables: median household income, total expenditures per pupil, and student-teacher ratios. For measuring outputs, graduation rates and eighth grade reading scores are employed. Data for student-teacher ratios and graduation rates are compiled from IES and NCES, for the period 2008-2009. The IES was established under the Education Science Reform Act of 2002. With an annual budget of over $200 million, the IES seeks to provide and share relevant data in order to broadly improve education policy. The NCES is the primary federal entity for collecting and analyzing educational data. The 2009 median household incomes by state and total expenditures per pupil are obtained from the US Census Bureau (2010a, b). Following is a discussion of each selected variable (Table I).

	Median income	Total expenses per pupil	Student/ teacher ratio	Graduation rate	Eighth grade reading
Maximum	64,851.00	14,531.12	19.89	0.91	272.00
Minimum	35,078.00	7,813.27	11.70	0.56	251.00
Mean	49,010.32	10,162.46	14.90	0.75	261.77
Standard deviation	8,502.51	1,784.72	2.22	0.08	5.76
Type	Input	Input	Input	Output	Output

Table I. Descriptive statistics for variables

It is apparent that socioeconomic and environmental factors can greatly impact student performance. Many DEA studies have supported this argument. For example, Ketkar and Noulas (1998) found that wealthier school districts in New Jersey had higher efficiency scores than poorer districts. However, the difference between the efficiency scores became smaller when an adjustment was made for socioeconomic factors such as median household income. Similarly, Ruggiero (2007) used median income as an input variable in his application of DEA analysis to Ohio schools. As stated in his work, "median district income was used to control for the socio-economic environment." Because our study encompasses a large variety of environments, namely states with varying degrees of resources, it is practical to use an input such as median household income as an indicator of the socioeconomic environment that each state operates within.

Historically, it seemed reasonable to address inefficiencies in the public education system by increasing funding levels. However, studies have shown that injecting more money into the system does not always result in higher student achievement levels. DEA analysis can be a useful tool when allocating scarce resources. Chalos (1997) chose operating expenses per pupil as one of the input variables and found that efficient school districts spent less than inefficient districts did. Similarly, Ruggiero (2000) found that approximately 80 percent of New York state schools could have provided the same level of outcome by using fewer of the observed inputs. He included per pupil expenditures on salaries and on instructional materials as input variables. Conversely, Thanassoulis and Dunstan (1994) chose to ignore funding amounts in their study on school performance in the UK. They reasoned that funding levels could not be influential across schools in the UK. Funding levels can vary greatly by state, as they are dependent upon diverse governmental policies and decisions. Budget allocation decisions may be influenced by organized labor groups, such as teacher unions. We include total expenditures per pupil as an indicator of resource appropriation among states.

A common input variable used in evaluating public education is the student-teacher ratio. The familiar understanding is that lower class sizes can favorably impact student performance, since students have the advantage of more individualized instruction. The number of teachers to students is a discretionary input, controlled by schools or school districts. Cordero-Ferrera *et al.* (2008) noted that student-teacher ratios and personnel costs were the two variables most often used as controllable inputs when applying DEA to public school systems.

Measuring the outcome of educational systems provides many challenges. In most industries, there are easily identifiable production functions. That is, the relationship between inputs of capital and labor and outputs of goods and services can be accurately predicted. However, educational outputs can be difficult to measure, compile, and interpret. For example, common output variables such as graduation rates and standardized test scores are based on formulas and criteria, which can vary from state to state. Nevertheless, graduation rates and various composite test scores are often used to measure student performance. Chakraborty *et al.* (2001) used a composite of reading, writing, and math skills of 11th graders as their sole output. Ruggiero and Vitaliano (1999) used both graduation rates and standardized test scores, along with dropout rates for measuring student performance. Hanushek (1993) reviewed 187 studies and found that 70 percent of them used standardized test scores.

Hypotheses

Due to a recent unprecedented recession, many states in the USA suffer budgetary shortfalls. As a consequence, some states such as Wisconsin and Ohio have attempted to

limit the rights of teacher unions by raising questions on student performance and budgetary efficiency. Teacher unions are now in the heart of the debate regarding political and social issues. To address these issues in a timely manner, we assess the efficiency of schools at the state level in two stages. First, we dichotomize states by the levels of unionization such as 11 least unionized (2 percent or less) and 11 highly unionized (87 percent or more) and evaluate their efficiency using the bilateral DEA models that are good for comparing two groups of DMUs. Next, we rank the states using the efficiency scores computed by the models and conduct non-parametric rank-sum tests. Applying different DEA models, we can identify the sources of inefficiency such as pure managerial aspects (PTE), different operating conditions (SE), and input excesses/output shortfalls (MIX). We compare the two groups of states using a bilateral BCC model for PTE, a bilateral CCR model for TE that is the product of PTE and SE, and a bilateral SBM for SBM, which is the product of TE and MIX. First, we attempt to detect the performance difference between less unionized and highly unionized states from a pure managerial perspective. We test the following hypothesis using the bilateral BCC model:

H1. There is no performance difference between the two groups of states from a pure managerial perspective.

Second, in addition to pure managerial efficiency, we consider operating conditions for measuring the performance or efficiency of the two groups. The pure managerial efficiency is about the efficiency determined by internal factors. Meanwhile, SE reflects external factors. The bilateral CCR model measures the PTE and SE for the two groups. We test the following hypothesis:

H2. There is no performance difference between the two groups from internal and external perspectives.

Third, we test the last hypothesis using the bilateral SBM model that measures the efficiency for internal and external factors along with input excess and output shortfalls or MIX:

H3. There is no performance difference between the two groups measured by the bilateral SBM model.

Results and discussion

Using the efficiency scores of the three bilateral models, we ranked the states and performed Mann-Whitney rank-sum tests. The summary of test results is shown in Table II.

The *p*-values for the rank-sum statistics in Table II are all significant at $\alpha = 0.025$ or less. Thus, we reject all three hypotheses. There are statistically significant performance differences between the two groups of states measured by the three DEA models. The *p*-value on the PTE difference is most significant. That is, the highly unionized states

		Bilateral PTE		Bilateral TE		Bilateral SBM	
	n	Rank sum	*p*-value	Rank sum	*p*-value	Rank sum	*p*-value
Group 1	11	75	0.000**	92	0.012*	88	0.006**
Group 2	11	178		161		165	

Notes: *Significant at $\alpha = 0.025$; **significant at $\alpha = 0.01$

Table II.
Summary of rank-sum statistics

show lower performance from a pure managerial perspective (*H1*). When we consider internal and external factors together (*H2*), it becomes less significant. Thus, we can say that, at least, external factors measured with SE do not aggravate the performance of the highly unionized states since TE = PTE × SE. In addition, the *p*-value on the MIX difference is larger than that on PTE. This indicates that input excesses or output shortages do not adversely affect the performance difference of the two groups. Accordingly, we can conclude that the lower performance of the highly unionized states is mainly due to the internal or pure managerial factors.

Although the difference on PTE is the most significant, it is necessary to examine the overall efficiency computed with an SBM model for post-analysis, which is the product of TE and MIX (overall or SBM efficiency = TE × MIX = PTE × SE × MIX). To identify the variables that influence inefficiency in the bilateral SBM model, we pool the two groups and run an output-oriented SBM model with constant-returns-to-scale. It is necessary to utilize the output-oriented SBM model to avoid the problem with one of the input variables, median household income, which is uncontrollable by the administrators of schools. Besides, an output shortfall, which can be measured with an output-oriented SBM model, means generating fewer outputs using given inputs. In this case, we focus on a remedy to increase outputs. Table III exhibits the decomposition of inefficiency of two output variables and projection or increases of the variables for the inefficient states.

The letters L or H after the state names in Table III represent the level of unionization such as L for a less unionized state and H for a highly unionized state. Because the decomposition of ineffic14iency is the purpose of analysis in Table III, we include the inefficient states only. The relationship between SBM efficiency scores and output inefficiency scores is as follows: SBM efficiency = 1/[1+(graduation rate inefficiency)+(ACT composite inefficiency)], where graduation rate inefficiency represents the inefficiency of "graduation rate" and ACT composite inefficiency shows the inefficiency of "ACT composite score." These inefficiency scores are outputs of the SBM model. Using this relationship, we identify influential variables on DMUs' efficiency scores. For example, the states of Georgia and Nevada suffer low efficiency scores mainly due to the inefficiency of their graduation rates. As revealed by the mean

Table III.
Decomposition of inefficiency and projection by an output-oriented SBM model

	Efficiency score	Output shortage: graduation rate inefficiency	Output shortage: reading score inefficiency	Projection of graduation rate (%)	Projection of reading score (%)
Alabama-L	0.9306	0.0483	0.0262	9.67	5.25
Florida-H	0.9426	0.0571	0.0038	11.41	0.76
Georgia-L	0.8757	0.1083	0.0336	21.66	6.72
Hawaii-H	0.7757	0.1550	0.1341	31.01	26.82
Illinois-H	0.8426	0.1080	0.0789	21.59	15.78
Maryland-H	0.8591	0.0894	0.0745	17.88	14.91
Nevada-H	0.8175	0.1855	0.0377	37.10	7.55
Oregon-H	0.8736	0.0682	0.0765	13.65	15.30
South Carolina-L	0.8744	0.1036	0.0401	20.72	8.01
Virginia-L	0.8118	0.1097	0.1222	21.94	24.43
West Virginia-L	0.9276	0.0258	0.0523	5.16	10.45
Wisconsin-H	0.9455	0.0013	0.0564	0.26	11.27
Mean	0.8731	0.0884	0.0564	17.67	12.27

inefficiency scores in Table III, inefficient states need to pay more attention to their graduation rate. Meanwhile, the states of Virginia and Wisconsin are inefficient because of the influence of their eighth grade reading scores. To eliminate these inefficiencies, the states should look at projections of the variables shown in two columns in Table III. For example, to be efficient, the state of Nevada needs to increase their graduation rate by 37.1 percent. Similarly, the state of Hawaii should increase eighth grade reading scores by 26.82 percent. Mean inefficiency and projection rates confirm that the inefficient states have to work mostly on the graduation rates. We then compute the mean inefficiency for the two groups. Table IV shows mean efficiency scores for the less unionized states and the highly unionized states.

Similar to Table III, where our analysis is on the inefficient states, we include only the inefficient states in Table IV. The highly unionized states maintain higher inefficiency scores on all output variables than the less unionized states do. For both groups, the major source of inefficiency is the graduation rate. Bottom line, all inefficient states, regardless of their level of unionization, need to pay more attention to their graduation rates.

We measured the comparative performance of schools at the state level in the USA using multi-stage analyses, which was the first attempt in this area. Although our approach contributes to the literature of this topic by employing a novel framework, caveats in our study such as the choice of variables and models are not negligible. Thus, we invite further studies on this topic within various perspectives for confirming the influence of teacher unions on public education.

Conclusion

The US public is right to be concerned about the condition of our educational system. Resources are scarcer than ever during these recessionary times. School administrators have an obligation to use financial resources wisely, while improving student achievement. The decades of throwing money at the problem have not solved the pressing issue of student performance. Teacher unions are helpful for improving working conditions, providing benefits, and for affording stability to teachers in the form of job security and compensation. However, the goal of attaining greater student achievement may not be served well by the collective bargaining agreements that are so beneficial to the educators.

Many studies that include student achievements and socioeconomic factors have examined the performance of various education systems in different regions. However, there is no study available for evaluating the performance of schools by controlling the effect of teacher unions at the state level. This study examines the impact of unionization on the efficiency of state educational systems using DEA models. We classified two groups of states, those with high unionized status and those with low union participation. Once the groups were identified, a two-stage approach was applied to the data. First, the performance of schools at the state level was evaluated using three bilateral DEA models. Next, Mann-Whitney rank-sum tests were employed to

Table IV. Mean inefficiency by less unionized and highly unionized states

	Number of states	Graduation rate inefficiency	Reading score inefficiency
Less unionized states	5	0.0792	0.0549
Highly unionized states	7	0.0949	0.0660

consider three hypotheses. Based on the rank-sum statistics, we rejected the three hypotheses that assumed no difference on the schools' performance in three categories: pure managerial factors, operating conditions, and input/output mixes. Our analysis found that the highly unionized states showed lower performance than the less unionized states.

A post-analysis was conducted using an output-oriented bilateral SBM model to further evaluate the variables behind the statistically significant differences identified in the previous stage. In this analysis, we were able to identify the major factor that affected the performance of the schools to assist managers and administrators with their policy and strategy decisions. Namely, the inefficient schools need to focus primarily on increasing their graduation rates.

Government officials and school administrators can be influenced by union members when they make decisions regarding budget allocations to the educational system. Studies utilizing DEA analysis may prove useful in identifying the extent to which student outcomes are impacted by differences in DMUs, such as the degree of unionization. While this DEA analysis revealed differences in the efficiency ratings between the two groups, the debate surrounding teacher unions and associations is likely to continue, as differences in socioeconomic variables continue to, and sometimes increasingly so, impact the educational systems' performance.

Major contributions of our study include a novel approach for measuring the performance of primary and secondary schools at the state level by classifying and choosing less or highly unionized states and suggesting insights for improvements. The purpose of this study was to conduct a comparative analysis of specific variables. It should not be viewed as a definitive analysis or incontrovertible conclusion drawn on the relative merits of unionized vs non-unionized units. Limitations of our study are the choices of variables, models, and levels of analysis. To overcome these issues, future studies need to consider different variables and models in various perspectives.

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Further reading

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Appendix

State	Collective bargaining	Meet-and-confer discussion	No specific agreement
Alabama (N)	0.0	43.5	56.5
Alaska	80.9	13.1	6.0
Arizona (N)	0.4	14.4	85.2
Arkansas (N)	1.5	9.7	88.7
California	82.3	5.2	12.6
Colorado	28.7	20.4	51.0
Connecticut (U)	91.5	5.7	2.8
Delaware	61.0	0.0	39.0
District of Columbia	10.3	0.0	89.7
Florida (U)	90.2	7.4	2.5
Georgia (N)	0.0	1.2	98.8
Hawaii (U)	100.0	0.0	0.0
Idaho	70.2	15.8	14.0
Illinois (U)	88.7	6.0	5.3
Indiana	80.1	15.1	4.8
Iowa (U)	95.6	4.4	0.0
Kansas	58.0	32.9	9.1
Kentucky	6.4	8.6	85.0
Louisiana	10.5	6.8	82.6
Maine (U)	93.0	7.0	0.0
Maryland (U)	91.6	4.4	4.0
Massachusetts	83.1	5.2	11.7
Michigan	66.4	4.2	29.4
Minnesota	45.7	34.9	19.4
Mississippi (N)	1.3	0.0	98.7
Missouri (N)	0.9	35.3	63.9
Montana	60.7	8.4	30.9
Nebraska	80.3	13.2	6.5
Nevada (U)	100.0	0.0	0.0
New Hampshire (U)	94.4	0.0	5.6
New Jersey	80.8	13.6	5.6
New Mexico	31.2	7.5	61.4
New York	81.0	9.1	9.8
North Carolina (N)	0.4	6.0	93.6
North Dakota	56.5	18.4	25.1
Ohio	75.5	2.6	21.9
Oklahoma	22.7	11.2	66.1
Oregon (U)	92.1	6.0	1.9
Pennsylvania	75.3	9.0	15.7
Rhode Island	69.6	10.4	20.0
South Carolina (N)	0.8	0.8	98.4
South Dakota	59.4	25.9	14.7
Tennessee	66.3	15.8	17.9
Texas (N)	0.0	2.2	97.8
Utah	24.0	36.5	39.4
Vermont	87.3	12.7	0.0
Virginia (N)	0.0	20.6	79.4
Washington	67.7	12.5	19.8
West Virginia (N)	0.0	11.6	88.4
Wisconsin (U)	88.6	11.0	0.5
Wyoming	1.8	42.1	56.1
USA	53.5	10.9	35.6

Notes: There are rounding errors. N, less unionized; U, highly unionized

Table AI. Specific teacher association or union agreements in percentages

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