Adv Educ Res Eval, 2020, 1(2): 79-87
DOI: 10.25082/AERE.2020.02.004

RESEARCH ARTICLE

Drivers of school performance over time: Evidence from public schools in the United States

Allison Jennifer Ames[1*] Simone Angioloni[2] Glenn C. W. Ames[3]

Abstract: Few studies have analyzed the effect of the drivers of school performance over time. This research investigates how school-level student characteristics, such as funding and student-teacher ratio, influence school academic performance in the short-term and in long-term, a key differentiating feature of this work from other studies. Our focus is on the United States state of Georgia, but the setting of Georgia reflects conditions throughout the U.S.: considerable variation between schools in achievement and resources. In this study, school performance is defined as the proportion of students that meet or exceed benchmarks on end of year exams. Study findings indicate that teacher experience, measured by average number of years teaching, and student-teacher ratio exhibit the largest effect in both the short and long-term. Poverty rate exhibited a strong negative effect on school performance, confirming previous studies. However, poverty rate had the most impact in the STEM subjects of math and science. School funding did not show any significant effect in school performance in the short-term, but a significant positive effect in the long-term, such that increased school funding per pupil improved school performance in future years. Our results indicate that investing resources to increase the number of teachers and hiring teachers with more experience can be economically more effective than simply increasing the per-pupil spending, at least in the short-term.

Keywords: school performance, school resources, achievement gap, effects over time, STEM

1 Introduction

School resources such as funding, quality and experience of teachers, learning environment, and infrastructure affect individual student performance and, taken together, school performance as measured by the percentage of students who meet or exceed state mandated levels of competence[1–3]. Wide disparities characterize education-funding levels among states in the United States (U.S.), ranging from $18,165 per pupil in New York State to $5,838 in Idaho in 2014. Even when accounting for regional costs differences, the U.S. state of Georgia ranked No. 38 in the nation in educational funding per student at $8,067[4]. Deep cuts to public education funding in the last 16 years, 2003 to 2018, reduced state funding by $9 billion[2]. When the state reduces funding for education, local property taxes cover the shortfalls where possible in Georgia, where, on average, local taxes generate about 40% of the funding for K-12 education in Georgia.

In addition, there are large differences in funding among school districts within the same U.S. state, prompting development of an equity factor under Title I Part A of the No Child Left Behind Act. School districts with smaller tax bases, such as those in rural areas, are disproportionately affected by spending cuts. In the geographic center of the state of Georgia, for example, 13 years of austerity cuts have been especially detrimental to school districts where many school districts are worse off than 10 years ago[5]. School districts with declining revenue from property taxes responded by furloughing teachers, increasing class sizes, and eliminating elective subjects and extracurricular activities altogether[2].

In the U.S., the proportion of students meeting or exceeding a standard on standardized testing determines the level of school performance, which many states review annually. Moreover, schools that do not meet the criteria can be threatened with administrative takeover. In 2017, the Georgia General Assembly created the position of Chief Turnaround Officer to work closely with low-scoring schools to design and implement reforms to raise

Received: March 25, 2020 **Accepted:** May 25, 2020 **Published:** June 1, 2020

* **Correspondence to**: Allison Jennifer Ames, Educational Statistics and Research Methods Program, College of Education and Health, University of Arkansas, USA; Email: boykin@uark.edu

[1] Educational Statistics and Research Methods Program, College of Education and Health, University of Arkansas, USA

[2] Economics Research Branch, Agri-Food Biosciences Institution, Belfast, UK

[3] Department of Agricultural & Applied Economics, University of Georgia, Athens, GA, USA

Citation: Ames AJ, Angioloni S and Ames GCW. Drivers of school performance over time: Evidence from public schools in the United States. *Advances in Educational Research and Evaluation*, 2020, **1**(2): 79-87.

students' preference to meet state-mandated standards[3].

This study uses school-level data for several reasons. First, numerous studies indicate that a school's characteristics, such as poverty, high student-teacher ratio, and limited funding, among others, shape the students' learning experience and educational performance[6–8]. Second, educational policymakers hold schools accountable for the academic performance of their students, recognizing and rewarding schools according to the aggregate student performance on standardized tests. That is, schools are not rewarded for individual students' performances, but how the school does as whole. Currently, the Governor's Office of Student Achievement uses the annual College and Career Ready Performance Index (CCRPI) to determine which public schools, mainly elementary schools, will be placed on the state's list of Turnaround Eligible Schools. CCRPI scores are based mainly on aggregated student scores on end of year achievement tests at the school level. Third, this approach has a clear interpretation. The school's characteristics can be considered inputs in the educational production function, whereas the achievement score is the output[9, 10].

In this environment, a school's achievement scores impact future resources for the school. Schools may be located in geographical regions that are characterized by poor provision of basic services, reduced job opportunities, low income, racial segregation, and a high concentration of single-parent families. The result is clusters of low-performing students in low-performing schools, as measured by the percentage of students meeting state mandated levels of competency on annual standardized tests. This generates a devastating cycle of inequality: low performing schools have a limited capability to attract resources and this generates further inequality over time. Georgia has a complex school funding mechanism known as the Quality Basic Education formula that aims to reduce the disparities in local district resources for education. Georgia offers equalization grants to schools, but these grants have been reduced, especially during the Great Recession when the state collected less tax revenue. For a discussion of reestablishing the level of equalization grants to local school districts at a higher percentage level see Owens[2, 11].

1.1 Poverty, school resources, and school performance

The long-term consequences of the Great Recession, which began in 2007, greatly amplified the impact of poor resources on school performance. In the U.S., the recession translated into tighter budgets and decreased spending per pupil. For example, in Georgia, the state reduced funding to local school districts by $1 billion annually from fiscal years 2010 to 2014[3]. Additionally, part of the school resources financed through local property taxes substantially declined during the Great Recession. The consequences of funding cuts included larger class sizes and reduced support staff, such as social workers, counselors, and intervention specialists[3]. Moreover, increased expectations for student achievement simultaneously accompanied fiscal austerity. Combined, these factors created a disconcerting scenario for educational achievement.

Among the socio-economic factors that affect educational achievement, poverty and hunger play a fundamental role. The percentage of students in a school who qualify for the federal National School Lunch Program (NSLP), which provides free and reduced-priced lunches, captures some of this socio-economic environment affecting schools. For example, Figure 1 illustrates the relationship between the poverty rate, as measured by the percentage of students eligible to participate in the free or reduced-price lunch program and the percentage of the 4th grade students that met or exceeded the standard of the Georgia Criterion-Referenced Competency Tests (CRCT) in mathematics. In general, a strong inverse relationship is present throughout the state. The negative, heterogeneous relationship appears persistent over time; no apparent substantial changes in these relationships were observable between 2011 and 2014.

Reardon[12] summarized much of the research on the widening income-academic achievement gap of U.S. students over the last 50 years and concluded that structural changes in the economy, widening income inequality, changing family structure, the college completion rate among high versus low-income families, and other factors have had important consequences for children's academic success and future career (p. 6). Furthermore, academic success has become increasing equated with standardized test scores for parents, school districts, state and national policy makers. Reardon further argues that states and school districts should devote greater resources and educational efforts to the earliest grades, including kindergarten and preschool, because academic achievement gaps are self-perpetuating. Early intervention is warranted if educators want to reduce them or eliminate them in the long run (p. 6).

In addition to poverty, there are a series of related educational and socio-economic factors, such as per pupil spending and the student-teacher ratio, affecting the performance of a school in the short- and long-term. However, there has been little research on the lasting impact of these factors on academic achievement across multiple time periods. Bjorklund-Young[13] summarizes the leading research on the fundamental question, "Does an

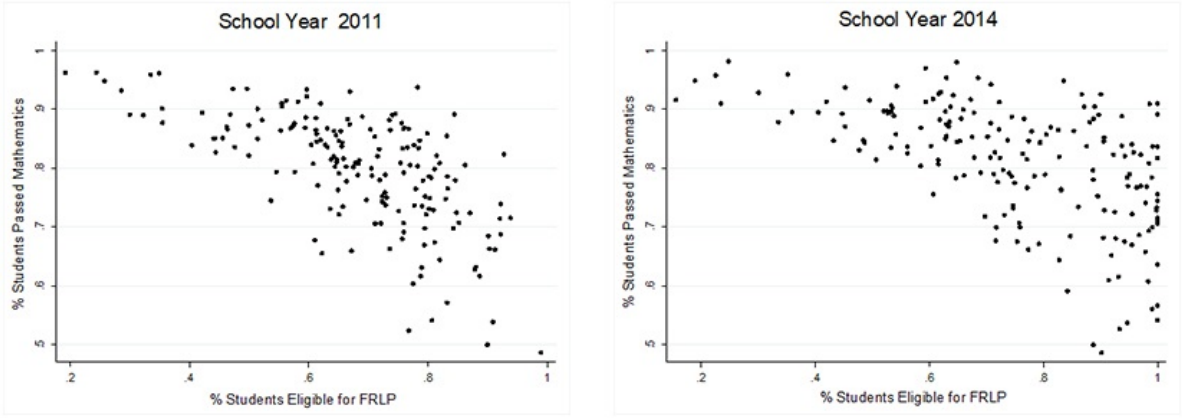

Figure 1: Mathematics Achievement Score and Poverty Rate in Georgia Public Schools, 2011 & 2014. School district averages weighted by the number of students

increase in education funding yield better educational outcomes?" She concludes that "Prominent researchers, including the sociologist James Coleman and the economist Eric Hanushek find no significant relationship between funding and educational outcomes, usually defined as student achievement on standardized tests" (p. 1). However, more recent findings[14] show that increased funding can improve educational outcomes, when that funding is spent on specific kinds of programs or improvements.

Jackson *et al.*[14] measured the impact of increased school funding on student learning by using long-run student outcomes, such as educational attainment, high-school graduation, adult wages, adult family income, and incidence of poverty as an adult. They find evidence that funding for specific initiatives, such as increased instruction, better support services, decreased teacher-student ratios, longer school days, and increased teachers' salaries, can be an effective way to boost student achievement under certain circumstances[14].

While many long-term outcomes are associated with test scores—for example, students with higher test scores are more likely to graduate from high school—there are additional benefits for the school system and the wider economy. Jackson *et al.* concluded that increasing per-student spending by 10% in each of the 12 years a student is in school increases the number of years students attend school by 0.3 years, increases future wages by 7%, and decreases annual adult poverty by 3.2 percentage points, on average. Further, the study finds that these effects are larger for students from low-income and minority backgrounds[14].

1.2 School-teacher ratios

Numerous studies indicated that lower student-teacher ratios can improve student performance, especially in scientific subjects such as mathematics and physics[15, 16]. Schools with higher student-teacher ratios are usually located in inner city public schools[12]. Moreover, consolidated research indicated that pupils who attended schools with a lower student-teacher ratio can earn a higher wage as adults than pupils from schools with higher student-teacher ratios[17].

Hirn, Hollo and Scott[18] analyzed teaching practices inside the classroom that predict student success in schools where most students live in poverty. Their results "supported the hypothesis that teacher-student interactions differed in high- and low-achieving schools" (p. 43). Teachers in high-preforming schools provided students with more frequent opportunities to respond to group-directed instructional activity than in low-preforming schools. They also cited other research that showed that high-poverty neighborhood schools tended to employ teachers with less experience, lower levels of education, and lower retention rates than schools in wealthier areas (p. 38). Years of teacher experience is an important factor the level of academic performance for students and schools in this study.

1.3 Research questions

A review of the relevant literature raises important research questions about factors affecting school performance in Georgia. Our specific research questions are: Does an increase in school resources, such as funding, yield better school performance when differentiated by subject matter? How does the poverty rate of the surrounding communities, as measured by the share of students eligible to participate in the National School Lunch Program, impact school performances? How do years of teachers' experience and student-teacher ratios impact school performance? These seemingly straightforward

questions have yet to be explored over multiple years and across subject matter.

The purpose of this research is to extend previous work on the drivers of school performance, with an emphasis on both the short- and long-term effects of school-level resources and educational achievement, focusing on public schools in Georgia during a four- year span from 2011 to 2014, a period immediately after the Great Recession. Specifically, this study analyzes the relationship between a series of socio-economic status factors and the short- and long-term effects on school performance using response elasticities. An additional contribution of the study is that we differentiate the results by academic subject, namely Reading, Mathematics, English Language and Arts (ELA), Social Studies, and Science.

The balance of this paper is organized as follows: the method section describes the econometric approach employed to estimate the short and long-term effects and the strategy to control for endogeneity and the data sources and the definition of the variables. Then we show the results while the conclusions and implications are drawn in the final section.

2 Methods

To investigate the relationship between socio-economic factors and achievement scores, panel-data techniques are employed in this research for each academic subject area. When the school's characteristics affect the current and future educational performance of its students, it is plausible that this effect progressively decreases over time. That is, the current characteristics have a stronger effect on the school performance than the characteristics one period ago, two periods ago and so on (*inertia*). If so, the persistent effect of the school's characteristics on the achievement score can be modelled by lagging the dependent variable, *i.e.* the achievement score[19,20]. Specifically, the estimated model is:

$$y_{it} = \lambda y_{it-1} + \beta_0 + \beta_1 \chi_{1it} + \cdots + \beta_\kappa \chi_{\kappa it} + \varepsilon_{it} \quad (1)$$

where the subscripts *i* and *t* identify the i^{th} school and the t^{th} time period (t = 4 for years 2011- 2014). The dependent variable, y_{it-1} is an indicator of academic achievement and the lagged dependent variable, y_{it}, is an indicator of academic achievement in the previous time period. For this study, y_{it} is subject-specific and represents, for example, end of grade scores for mathematics achievement in time *t*. Specifically, the dependent variable represents the proportion of children achieving proficiency in the end of grade test. End of grade scores (proportion of children achieving proficiency) for mathematics achievement in the previous year would be represented by y_{it-1}.

The κ independent variables are represented by $\chi_1 \ldots \chi_\kappa$. Both the dependent variable and all bounded independent variables were log-transformed. The error term ε_{it} is assumed to follow an autoregressive process of order one (*i.e.*, *AR*(1)). More precisely, lagging the dependent variable generates an *AR*(1) process of the error term by construction[20]. The resulting β_κ estimates from the model in Equation (1) represent the short-term response elasticity. For example, if $\beta_{povertyrare}$ = -0.03, the interpretation is that a 1% increase in the poverty rate of the school decreases the percent of proficient students in the specific subject by .03%. The λ parameter is the coefficient of the lagged dependent variable. The long-term elasticity is β_κ/(1-λ).

This statistical modeling approach has several advantages. The inclusion of the lagged dependent variable allows the unobserved heterogeneity, which is the unobserved quality of the school in this study, to be correlated with the observed school's characteristics, and this should control for the omitted variable bias[21,22]. Second, traditional techniques, such as fixed effects models, can produce inconsistent estimates and too large standard errors when the panel-data exhibits limited within-groups variation[23–25]. Table 1 indicates that the between-groups variation explains at least 75% of the total variance of the achievement score in all the academic subjects. Third, adding a lagged dependent variable allows for testing of the relationship between school resources and school performance *over time*. In particular, it will be possible to recognize between short-term effects from long-term effects.

Table 1 Analysis of variance of the achievement scores (multiplied by 100)

Variable	Sum of Squares	
	Within-Groups Variation	Between-Groups Variation
Reading	7.84 (0.25)	23.33 (0.75)
ELA	7.04 (0.20)	27.83 (0.80)
Social	15.53 (0.14)	95.66 (0.86)
Math	13.6 (0.17)	66.67 (0.83)
Science	12.42 (0.13)	80.44 (0.87)

Note: In parenthesis, the percentage of the total variation due to the group variation

2.1 Data and definition of the variables

The data come from three sources: the Georgia Department of Education[26–28], the Governor's Office of Student Achievement[29], and the National Center for Education Statistics[30]; see Table 2. Georgia law mandates an annual assessment of students' mastery of the curriculum for students in grades one through eight[27]. These examinations are referred to as the Georgia Criterion-Referenced Competency Tests (CRCT) in reading/English/language

Table 2 Variable definitions and source

Variable Name	Description	Source
Reading	Share of 4th grade students who met or exceed the standard of the CRCT in reading (dependent variable).	Georgia Department of Education
ELA	Share of 4th grade students who met or exceed the standard of the CRCT English language and arts (dependent variable).	Georgia Department of Education
Social	Share of 4th grade students who met or exceed the standard of the CRCT in social studies (dependent variable).	Georgia Department of Education
Science	Share of 4th grade students who met or exceed the standard of the CRCT in science (dependent variable).	Georgia Department of Education
Mathematics	Share of 4th grade students who met or exceed the standard of the Criterion Reference Competence Test (CRCT) in mathematics (dependent variable).	Georgia Department of Education
Poverty Rate	Share of 4th grade students eligible to participate in the free or reduced-price lunch program under the National School Lunch Act.	National Center for Education Statistics
School Size Proxy (Students)	Number of 4th grade enrolled students in the school.	National Center for Education Statistics
Teacher Experience	Average Years of Experience of PK-12 teachers in the school.	The Governor's Office of Student Achievement
Student-Teacher Ratio	Full-time equivalent students divided by full-time equivalent teachers in the school.	The Governor's Office of Student Achievement
Absenteeism (days)	Average number of absenteeism days in the school.	The Governor's Office of Student Achievement
Annual Spending Per Student (USD)	Annual spending per full-time equivalent student in the school.	Georgia Department of Education

Note: Annual spending per student adjusted with the Consumer Price index of the Atlanta-Georgia area 2011 base year[36]

Table 3 Mean and Standard Deviation of Variables for Academic Years 2011-2014

	2011 Mean (SD)	2012 Mean (SD)	2013 Mean (SD)	2014 Mean (SD)
English Language Arts (ELA)	89.95 (8.34)	89.03 (8.88)	89.03 (8.88)	87.49 (9.47)
Mathematics	78.72 (14.2)	82.75 (13.02)	82.75 (13.02)	80.03 (14.14)
Reading	89.14 (8.91)	91.62 (7.2)	91.62 (7.2)	92.84 (6.79)
Science	79.22 (14.46)	81.06 (13.9)	81.06 (13.9)	79.03 (14.9)
Social Studies	76.67 (16.48)	79.33 (15.28)	79.33 (15.28)	79.11 (15.65)
Absenteeism (days)	5.99 (0.96)	6.91 (0.93)	6.32 (1.35)	7.00 (0.99)
Teacher Experience (years)	13.94 (2.44)	14.06 (2.45)	13.96 (2.48)	13.7 (2.53)
Poverty Rate	64.65 (25.07)	65.87 (25.12)	68.33 (26.45)	69 (27.14)
Spending Per Student (USD)	6218.87 (1695.89)	6099.62 (1674.93)	5852.99 (1623.72)	6001.88 (1703.15)
Student-Teacher Ratio	14.99 (1.81)	15.36 (1.87)	14.64 (1.85)	14.44 (1.84)
Number of Students	105.35 (49.17)	104.84 (49.01)	105.38 (50.49)	106.71 (51.69)

Note: Mean of the Reading, ELA, Social Studies, Mathematics, and Science variables is the percentage of students who met or exceeded the standard of the CRCT in academic year 2011-2014. Mean poverty rate is the average percentage of students who were eligible to participate in the free or reduced-price lunch program under the National School Lunch Act. Absenteeism data are provided in intervals: 0-5 days, 6-15 days, more than 15 days. The mean number of absenteeism days was calculated considering 2.5 days for the first interval 10.5 days for the second, and 23 days for the third one. SD represents the Standard Deviation. All the rates are multiplied by 100

arts and mathematics. The CRCT assess the students' knowledge and skills of the state mandated content standards for each grade level. Students in the third, fifth and eighth grades cannot be promoted to the next grade if they do not achieve grade level performance on the CRCT tests. In the 2014-2015 school year, the Georgia Milestones Assessment System (Georgia Milestones)[30] replaced the CRCT test. The Georgia Milestones is a more comprehensive examination, including a writing component, but the objectives of the assessments are similar. However, these two assessment systems cannot be combined, as the scale, student learning outcomes, and proficiency standards are not the same. Moreover, the CRCT test scores provide a larger time span than the Georgia Milestones and, consequently we focus on that measurement of school performance.

In this study, the independent variables are poverty rate (National School Lunch Program participation, NSLP), school size (number of students), teacher experience (average number of years teaching), student-teacher ratio, absenteeism rate (days per pupil), and spending per student in U.S. dollars. Summary statistics of the studied sample are provided in Table 3.

Admittedly, NSLP participation is an imperfect self-report for poverty. However, there is supported rationale for using NSLP as a proxy for poverty. Snyder and Musu-Gillette[31] detail the argument for and against using NSLP as a proxy for poverty and conclude, "Because the free/reduced price lunch eligibility is derived from the federal poverty level, and therefore highly related to it, the free/reduced price lunch percentage is useful to researchers from an analytic perspective." For this reason, we use NSLP participation rates to represent poverty rates in the school.

2.2 Model estimation

The models were all estimated in Stata version 13[32] using maximum likelihood estimation by allowing the variance-covariance matrix of the error term to follow an auto-regression with lag-1 (*i.e.*, $AR(1)$) process within a panel (*i.e.* a school), but being fixed across panels. All standard errors were computed using bootstrap methods (500 replications). Overall, the models exhibited good fit for all subjects. The coefficient of determination, R^2, indicates that the explanatory power of the model ranges from

Table 4 Model results: Estimation of the achievement scores in selected disciplines with respect to school and student characteristics

Dependent Variable	Reading		ELA		Social Studies		Math		Science	
	β	SE	β	SE	β	SE	β	SE	β	SE
Lagged Dependent Variable	0.68***	0.02	0.76***	0.02	0.74***	0.02	0.80***	0.03	0.84***	0.02
Poverty Rate	-0.01***	0.0014	-0.02***	0.002	-0.03***	0.0031	-0.03***	0.0044	-0.02***	0.0033
Number of Students	0.004*	0.0022	0.01**	0.0034	0.02***	0.01	0.01***	0.0046	0.01*	0.0047
Teacher Experience (years)	0.01***	0.0049	0.02***	0.01	0.04***	0.01	0.02*	0.01	0.03**	0.01
Student-Teacher Ratio	-0.03***	0.01	-0.04***	0.01	-0.11***	0.02	-0.06**	0.03	-0.06***	0.02
Absenteeism (days)	-0.001	0.01	-0.01	0.01	-0.01	0.01	-0.02	0.01	-0.005	0.01
Spending Per Student (USD)	0.01	0.02	0.02	0.04	0.05	0.07	0.03	0.05	-0.03	0.04
Constant	0.34***	0.12	0.71***	0.16	1.75***	0.31	0.71**	0.32	1.39***	0.29
$\hat{\varepsilon}_{it-1}$	0.33***	0.02	0.30***	0.01	0.33***	0.03	0.32***	0.01	0.24***	0.01
Sigma	0.05		0.07		0.12		0.12		0.11	
R^2	0.80		0.77		0.83		0.78		0.83	
F-test Overall Fit (9,1065)	636.73***		613.34***		767.32***		557.74***		812.66***	

Note: All the dependent and independent variables were log-transformed, SE are bootstrapped standard errors based on 500 replications drawn from 1,066 schools, ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively. Time fixed-effects are present for all models

Table 5 Short-term and long-term elasticities of the achievement score

	Short-Term Elasticities				
	Reading	ELA	Social	Math	Science
Poverty Rate	-0.01***	-0.02***	-0.03***	-0.03***	-0.02***
Number of Students	0.004*	0.007**	0.020***	0.012***	0.009*
Teacher Experience (years)	0.01***	0.02***	0.04***	0.02*	0.03**
Student-Teacher Ratio	-0.03***	-0.04***	-0.11***	-0.06**	-0.06***
Absenteeism (days per student)	-0.001	-0.01	-0.006	-0.018	-0.005
Spending per Student (USD)	0.01	0.02	0.05	0.03	-0.03
	Long-Term Elasticities				
	Reading	ELA	Social	Math	Science
Poverty Rate	-0.03***	-0.09***	-0.10***	-0.14***	-0.14***
Number of Students	0.01***	0.03***	0.08***	0.06***	0.06***
Teacher Experience (years)	0.04***	0.10***	0.15***	0.11***	0.17***
Student-Teacher Ratio	-0.09***	-0.15***	-0.44***	-0.32***	-0.34***
Absenteeism (days per student)	0.00	-0.04***	-0.02	-0.09***	-0.03**
Spending per Student (USD)	0.04***	0.09***	0.18***	0.15***	-0.17***

Note: The short-term elasticity corresponds to the coefficient of the poverty rate variable from Table 3. The long-term elasticity is $\beta_{st}/(1-\lambda)$ where β_{st} is the short-term elasticity and λ is the coefficient of the lagged dependent variable from Table 3. The statistical significance of the long-term effect is estimated with the delta method from the bootstrapped variance-covariance matrix. ***, **, and * indicates statistical significance at the 1%, 5%, and 10% level

0.77 for the English Language Arts (ELA) assessment model to 0.83 for Social Studies and Math models (see Table 4). Table 4 presents the estimated model coefficients and Table 5 summarizes the short term and long-term elasticities.

2.3 Ethics

Because this is a secondary analysis of aggregate data, the study is IRB exempt.

3 Results

3.1 Elasticities

In general, when all the variables of the regression equation are log-transformed, the coefficients indicate the *approximated* percentage change of the dependent variable for a one percent increase of the independent variable. However, when the magnitude of the estimated coefficients is around zero, as in this case, the coefficients can be interpreted as the *exact* change of the dependent variable, making the analysis of elasticity straightforward.

Regarding the short-term effects, the top panel of Table 5 indicates that four variables are statistically significant: poverty rate, teacher experience, student-teacher ratio, and residually, the number of students. With respect of the poverty rate, the direction and magnitude of the short-term elasticities are consistent across subjects, ranging from -0.1 for Reading to -0.3 for Social Studies and Math. This means, for instance, that if the percentage of students eligible for NSLP increases by 1%, the school achievement score in mathematics decrease by 0.03% in the short-term, *i.e.* next year.

3.2 Educational achievement

Additionally, the coefficients of teacher experience and the student-teacher ratio were in the hypothesized direction and were statistically significant (see Table 5).

As the amount of teacher experience increases, so do achievement scores in academic disciplines, as expected. Conversely, as the student-teacher ratio went up, student achievement declined. Teachers have less time to devote to their students' learning needs when administrative responsibilities in the classroom increase. Notice also that the number of students has a positive effect on the achievement score. School size is measured by the number of students enrolled in the 4th grade as an indicator of school size and there is substantial evidence of the positive effect of economies of scale in public education[9].

3.3 School spending per student

Finally, spending per pupil did not show any statistically significant short-term effect. While there was considerable variability in funding support per student throughout Georgia's elementary schools, total spending per student did not appear to influence educational achievement as much as other factors in the analysis, when controlling for the other variables in the model. This result is not surprising as ". . . decisions about resource use are made by many actors and at many different levels of the system, so very few, if any, resource decisions are controlled at the school site"[33]. Further, Roza states, "the reality for most schools is that they have little, if any, input into how resources are used in their schools"[33]. Individuals, state leaders, and distant stakeholders outside of the school site make resource decisions. This creates an unsavory environment for school-based accountability when federal and state policies are designed to hold schools responsible for student performance[33].

3.4 Long-term elasticities and educational achievement

The bottom panel of Table 5 presents the long-term elasticities. Long-term elasticity results indicate that the factors exhibiting the largest long-term effect on the school performance are related to the teacher characteristics, namely teacher experience and student-teacher ratio. Table 5 shows that the elasticities of the teacher experience range from 0.04 to 0.17 while those of the student-teacher ratio range from -0.09 to -0.44. This because the long-term effect represents the cumulative impact of a series of annual or short-term impacts. These results are consistent with the findings of Jackson, Johnson, and Persico[14], who concluded that funding for specific items such as lower teacher/student ratios can be an effective way to raise student achievement. Other research has also shown that primary school students, especially low-income students, benefit from smaller class sizes[34].

The long-term effect of the *poverty rate* on the school performance indicates an interesting pattern. These long-term elasticities range from for Reading to for Science and Math. In particular, Science and Math show a stronger negative effect: if the poverty rate increases by 1% in the current school year, this will decrease long-term STEM achievement scores by 0.14%. Thus, the impact of poverty is more persistent in the STEM subjects. Conversely, in the humanities, the long-term elasticities are smaller, but still negative. They are and for Reading, ELA, and Social Studies achievement scores, respectively. That is, the long-term impact of school-level poverty is smallest for Reading and largest for STEM subjects. Finally, although the short-term effect of spending per pupil and absenteeism are not statistically significant in any academic subject, they are in the long-term effects. Three out of five academic subjects show statistically significant elasticities at the 1%-5% level for the absenteeism rate.

4 Discussion and conclusions

Previous studies have rarely considered the differential effect of school resources on school performance over time. This research investigated this relationship with respect to five academic subjects: Reading, Mathematics, English Language Arts, Social Studies, and Science. We focused on the academic achievement of 4^{th} grade public school students in Georgia given the wide disparities that characterize the educational system of this country and this state in particular[2,4]. We employed a lagged dependent variable to control of (dynamic) unobserved school characteristics and to generate short and long-term effects. This allowed us producing robust results to test whether the school characteristics had a differential effect over time.

We found that the factors associated to the teacher characteristics, namely the teacher's experience and the student-teacher ratio, show the largest effect on the school performance, in the short and long-term. With respect to previous studies, we did not find that this effect is especially strong in scientific subjects[15,16]. Interestingly, we found that this differentiated effect is present for the poverty rate with STEM subjects (math and science) which are mostly affected in the short and long-term.

Our findings can help to explain the apparent ineffectiveness of school funding on the school performance indicated in previous studies[12,33]. Our results indicate that the short-term effect is not significant across the five academic subjects, but it is in the long-term. A possible explanation is the funding system in the U.S. is quite heterogeneous with overlapping of financial resources at the federal, state, and local level. Moreover, at the end of every academic years the most highly performing

schools are awarded with additional funding while supplementary financial resources are allocated to the lowest performing schools as part of legislative initiative and social programs[33]. The result is that all these resources are allocated on annual basis in an inconsistent way and their effect disappear, statistically speaking.

In terms of policy implications, our results suggest that the state and district budgets should plan the allocation of financial resources over several budget cycles according to the long-term school performance elasticity[14]. Our results indicate that investing resources to increase the number of teachers and hiring teachers with more experience can be economically more effective than simply increasing the per-pupil spending, at least in the short-term. Finally, poverty rate has a strong detrimental effect on the school performance, but this appears to be related to the community's socioeconomic situation and the enrollment boundaries of the school district; that is, the geographic area from where students are eligible to attend a school and where their families live and work[35].

Moreover, Reardon[12] argues that neighborhood schools are increasingly segregated by family income strata resulting in a social-class gap with children from lower income families having fewer resources to devote to learning readiness than higher income families (p. 3). He concluded that the widening income-academic achievement gap for children in U.S. is correlated to the extent to which families invest their time and money in their children's education. High-income families spend nearly seven times as much on their children's development as low-income families (p. 5). Thus, these conditions perpetuate a widening income-academic achievement gap over time.

Future research should extend the approach highlighted in this study to analyze the relationship between school resources and school performance for a longer period, ideally from the first grade to the eighth grade. This would allow for studying the persistence effects of school socioeconomic characteristics and resources on their performance over time. Whether these findings generalize to international education systems is another important area of study. In addition, the state of Georgia changed to the Georgia Milestones in the 2014-2015 academic year. Whether the trends found with the CRCT scores hold for the Georgia Milestones assessment is another important next step.

Another important predictor to be examined is the diversity of school faculty and administrators. In Georgia, students of color in education majors grew 14 percent from 2006 to 2014 while the increase in students of color in the overall student body amounted to a 10 percent increase[37]. The hiring of more teachers of color is an essential predictor in future research. Despite the need for future research, this study has contributed an important finding related to the drivers of short- and long-term achievement, differentiated by subject matter area.

Conflict of interest and funding

The authors have no conflict of interest to declare.

References

[1] Greer L. Common Core standards, 2013. http://www.senate.ga.gov/sro/Documents/AtIssue/atissue_June13.pdf

[2] Owens S. Beyond basic education: Five ways for Georgia to fund schools fairly, 2018. https://cdn.gbpi.org/wp-content/uploads/2018/12/Beyond-Basic-Education-Five-Ways-for-Georgia-to-Fund-Schools-Fairly.pdf

[3] Suggs C. Tackle poverty's effects to improve school performance, 2017. https://cdn.gbpi.org/wp-content/uploads/2017/12/Tackle-Poverty-in-Schools.pdf

[4] Baker B, Farrie D, Johnson M, *et al*. Is school funding fair? A national report card. Sixth edition. Newark: Education Law Center, Graduate School of Education, Rutgers University, 2017.

[5] Owens S. Georgia education budget primer for state fiscal year 2020, 2019a. https://gbpi.org/2019/georgia-education-budget-primer-for-state-fiscal-year-2020/

[6] Summers A and Wolfe B. Do schools make a difference? The American Economic Review, 1977, **67**: 639-652. https://www.jstor.org/stable/1813396

[7] Hanushek E. The Economics of schooling: Production and efficiency in public schools. Journal of Economic Literature, 1986, **24**: 1141-1177. www.jstor.org/stable/2725865

[8] Zimmer R and Toms E. Peer effects in private and public schools across countries. Journal of Policy Analysis and Management, 2000, **19**: 75-92. https://doi.org/10.1002/(SICI)1520-6688(200024)19:1⟨75::AID-PAM5⟩3.0.CO;2-W

[9] Bowles T and Bosworth R. Scale economies in public education: Evidence from school level data. Journal of Education Finance, 2002, **28**: 285-299. www.jstor.org/stable/40704168

[10] De Bartolome C. Equilibrium and inefficiency in a community model with peer group effects. Journal of Political Economy, 1990, **98**: 110-133. www.jstor.org/stable/2937644

[11] Owens S. Overview: 2020 fiscal year budget for K-12 Education, 2019b. https://cdn.gbpi.org/wp-content/uploads/2019/02/2020K12budgetoverview-FINAL.pdf

[12] Reardon S. The Widening Academic Achievement Gap Between the Rich and the Poor: New Evidence and Possible Explanations, New York: Russell Sage Foundation Press. 2011.

[13] Bjorklund-Young A. Does Money Matter? Hanushek, Jackson, and the Questions We Ask. Baltimore: Institute for Education Policy, School of Education, Johns Hopkins University, 2017.

[14] Jackson C, Johnson R and Persico C. The effects of school spending on educational and economic outcomes: Evidence from school finance reforms. Quarterly Journal of Economics, 2016, **131**: 157-218. https://doi.org/10.1093/qje/qjv036

[15] Blatchford P, Bassett P and Brown P. Examining the effect of class size on classroom engagement and teacher pupil interaction: Differences in relation to pupil prior attainment and primary vs. secondary schools. Learning and Instruction, 2011, **21**: 715-730. https://doi.org/10.1016/j.learninstruc.2011.04.001

[16] Van Hek M, Kraaykamp G and Perzer B. Do schools affect girls' and boys' reading performance differently? A multilevel study on the gendered effects of school resources and school practices. School Effectiveness and School Improvement, 2018, **29**(1): 1-28. https://doi.org10.1080/09243453.2017.1382540

[17] Card D and Krueger A. School quality and the return to education, in Gary Burtless (ed.) Does Money Matter? Effect of School Resources on Student Achievement and Adult Success. Massachusetts: Brookings Institute Press, 1996.

[18] Hirn R, Hollow A and Scott T. Exploring instructional differences and school performance in high-poverty elementary schools. Preventing School Failure: Alternative Education for Children and Youth, 2017, **62**(1): 37-48. https://doi.org/10.1080/1045988X.2017.1329197

[19] Keele L and Kelly N. Dynamic models for dynamic theories: the ins and outs of lagged dependent variables. Political Analysis, 2006, **14**: 186-205. www.jstor.org/stable/25791844

[20] Hamilton J. Time Series Analysis, Princeton: Princeton University Press. 1994.

[21] Angrist J and Pischke J. Mostly Harmless Econometrics, Princeton: Princeton University Press, 2010.

[22] Guryan J. Desegregation and black dropout rates. The American Economic Review, 2004, **94**: 919-943. http://doi.org/10.1257/0002828042002679

[23] Greene WH. Econometric Analysis, Harlow: Pearson Education Limited, 2010.

[24] Gravelle H, Jacobs R, Jones A, *et al*. Comparing the Efficiency of National Health Systems: Econometric Analysis Should Be Handled With Care. York: University of York Press, 2002.

[25] Deaton A. The Analysis of Household Surveys: A Microeconometric Approach to Development Policy, Baltimore: John Hopkins University Press, 1997.

[26] Georgia Department of Education. School system financial report, 2015. https://app3.doe.k12.ga.us/ows-bin/owa/fin_pack_revenue.entry_form?p_fiscal_year=2012

[27] Georgia Department of Education. CRCT statewide score, 2016a. http://www.gadoe.org/curriculum-instruction-and-assessment/assessment/pages/crct-statewide-scores.aspx

[28] Georgia Department of Education. School nutrition program, schools participating in cep (SY 2015-16) as of September 1 2015, 2016b. http://snp.wpgadoe.org/units/rtau/community-eligibility-provision/cep-percentages-2016-2018/

[29] Governor's Office of Student Achievement.Downloadable data, 2016. https://gosa.georgia.gov/downloadable-data

[30] National Center of Education Statistics. Public elementary/secondary universe survey data, 2016. https://nces.ed.gov/ccd/pubschuniv.asp

[31] Snyder T and Musu-Gillette L. Free or reduced-price lunch: A proxy for poverty? National Center for Educational Statistics blog post, 2015. https://nces.ed.gov/blogs/nces/post/free-or-reduced-price-lunch-a-proxy-for-poverty

[32] StataCorp. Stata Statistical Software: Release 13. College Station, TX: StataCorp LP,2013.

[33] Roza M. Education Economics: Where Do School Funds Go? Washington, D. C.: Urban Institute Press, 2010.

[34] Nye B, Hedges L and Konstantopoulos S. The effects of small classes on academic achievement: The results of the Tennessee class size experiment. American Educational Research Journal, 2000, **37**(10): 123-151. www.jstor.org/stable/1163474

[35] Lareau A and Goyette KA. Choosing Homes, Choosing Schools. New York, NY: Russell Sage Foundation, 2014.

[36] Bureau of Labor Statistics. BLS data viewer [data file], 2016. https://beta.bls.gov/dataViewer/view/timeseries/CUSR0000SA0;jsessionid=12A79D60522575A5105513FBF17C9D5B

[37] Partelow L, Spong A, Brown C, *et al*. America needs more teachers of color and a more selective teaching profession, 2017. https://www.americanprogress.org/issues/education-k-12/reports/2017/09/14/437667/america-needs-teachers-color-selective-teaching-profession/