December 2020

Teacher Effectiveness and Improvement in Charter and Traditional Public Schools

By Matthew P. Steinberg and Haisheng Yang

Foreword by Amber M. Northern and Michael J. Petrilli

THOMAS B. FORDHAM INSTITUTE
ADVANCING EDUCATIONAL EXCELLENCE

THOMAS B. FORDHAM INSTITUTE

ADVANCING EDUCATIONAL EXCELLENCE

About the Fordham Institute

The Thomas B. Fordham Institute promotes educational excellence for every child in America via quality research, analysis, and commentary, as well as advocacy and exemplary charter school authorizing in Ohio. It is affiliated with the Thomas B. Fordham Foundation, and this publication is a joint project of the Foundation and the Institute. For further information, please visit our website at www.fordhaminstitute.org. The Institute is neither connected with nor sponsored by Fordham University.

Suggested Citation For This Report

Matthew P. Steinberg and Haisheng Yang. *Teacher Effectiveness and Improvement in Charter and Traditional Public Schools*. Washington D.C.: Thomas B. Fordham Institute (December 2020). https://fordhaminstitute.org/national/research/teacher-effectiveness-and-improvement-charter-and-traditional-public-schools

Acknowledgments

This report was made possible through the generous support of the Walton Family Foundation and our sister organization, the Thomas B. Fordham Foundation.

We are grateful to authors Matthew Steinberg and Haisheng Yang for their careful approach, receptivity to feedback, and diligent adherence to timelines.

The authors would like to thank the Pennsylvania Department of Education for providing the data used in this study. And Steinberg also thanks David Volkman at the department for his institutional support and the Heinz Foundation for its financial support of research on human capital in Pennsylvania's schools.

External reviewers Dan Goldhaber, professor at the University of Washington, and Matthew Kraft, associate professor at Brown University, provided exceptional feedback on an early draft of the report. We also extend hearty thanks to project manager David Griffith for asking the right questions and skillfully pruning the final draft, to Chester E. Finn, Jr. for reviewing an earlier version of the draft, to Victoria McDougald for overseeing media relations, to Olivia Piontek for handling funder communications, to Pedro Enamorado for managing report production, and to Fordham research interns Tran Le and Trinady Maddock for providing assistance at various stages in the process. Finally, we thank Dave Williams for developing the report's layout and design, Pamela Tatz for copyediting the report, and FANDSrabutan from Getty Images for providing our cover image.

Contents

Foreword and Executive Summary

By Amber M. Northern and Michael J. Petrilli

Study after study has found that urban charter schools, and non-profit charter networks in particular, tend to be more successful at boosting student achievement than traditional public schools in similar settings. But why?

In recent years, the Thomas B. Fordham Institute has published several studies that provide partial answers to this question. *Student-Teacher Race Match in Charter and Traditional Public Schools*, by American University's Seth Gershenson, found that Black students in North Carolina charters are about 50 percent more likely to have a Black teacher than their traditional public school counterparts—which may help to explain why Tar Heel State charters are more effective at boosting the achievement of Black students. Similarly, *Teacher Absenteeism in Charter and Traditional Public Schools*, by Fordham's David Griffith, found that teachers in traditional public schools were almost three times as likely to be chronically absent as those teachers in charter schools.

Yet one riddle continues to perplex: We know from copious research that new teachers tend to be less effective than educators with more experience. But despite having a higher proportion of junior staff, urban charter networks often outperform their district peers.

So are charter school teachers just higher performing to begin with? Or are charter schools and/or charter management organizations (CMOs) particularly effective at helping new teachers improve faster?

Although there are plenty of well-known differences between charter and traditional public schools, very little is known about how teachers in charters improve over time—a gap that seems well worth filling, since schools of all types should be able to learn from one another when it comes to teacher recruitment, development, and retention.

Toward that end, we invited George Mason University associate professor Matthew Steinberg and University of Pennsylvania doctoral student Haisheng Yang to dig into how teacher effectiveness varies and evolves across traditional and charter public schools, as well as within the charter sector. Dr. Steinberg has published a number of studies on teacher quality and effectiveness, finance reform, and school discipline, including Fordham's first

report on discipline policy. He and Yang have also collaborated to examine principal mobility and professional development in Pennsylvania.

In this study, they use data on teachers who worked in Pennsylvania's charter and traditional public schools between 2007–08 and 2016–17 to investigate teacher effectiveness, improvement, and mobility across and between sectors. Pennsylvania is an ideal setting for such an investigation because the growth of its charter sector mirrors national trends, and because it has a healthy supply of both CMO and stand-alone charter schools.[1] Accordingly, Messrs. Steinberg and Yang examine academic outcomes for math and English language arts (ELA) for all students in grades three through eight, including those enrolled in both types of charter schools.

Readers are strongly encouraged to read the full report, which is thought-provoking, concise, and full of interesting statistics and figures. But for now, here's a summary of the key findings.

1. On average, teachers in Pennsylvania charter schools are more effective in English language arts but less effective in math than teachers in traditional public schools. *However, teachers in CMO-run schools are more effective in both subjects.*

2. Like teachers elsewhere, teachers in Pennsylvania become more effective as they gain experience, but teachers in the state's CMO-run schools improve more quickly than teachers in its traditional public schools or standalone charters.

3. Pennsylvania charter schools struggle with teacher retention, but CMOs retain and promote more effective teachers into leadership roles.

According to Steinberg and Yang, these findings suggest that Pennsylvania's CMOs are succeeding with "a fundamentally different approach to human capital" than the state's traditional public schools. But how exactly are they managing that?

In our view, this study offers evidence for two potential drivers. First, the second and third findings suggest that CMOs are better at systematically identifying and promoting their most effective teachers to instructional leadership positions (e.g., literacy coach or master teacher) where they can help other teachers improve—and by extension, help more students.

Second, the data indicate that CMOs are more likely to part ways with their least effective teachers. In fact, over 30 percent of CMO teachers exit their schools annually—voluntarily or involuntarily. Yes, that's a lot of turnover, and some of it is surely due to tough working conditions (including high expectations for teachers) and low pay (due to the substantial gaps in per-pupil funding between the sectors). Still, insofar as it's attributable to the exit of

ineffective teachers, higher turnover is a feature rather than a bug. And insofar as teachers who don't improve are more likely to leave, higher turnover might also explain why teachers who stay in CMO-run schools improve so quickly.

Of course, it's also possible that CMOs are doing a better job of recruiting smart and highly motivated teachers who are likely to improve more quickly. For example, one "School Leader's Toolbox" published by The New Teacher Project (now TNTP) urges schools to "define the Ideal Teacher...based on what type of teacher has been successful in your school" and to use the hiring process to set expectations by "communicat[ing] what is exciting and challenging about working at your school so that candidates are prepared for the school's culture and unsuitable candidates self-select out of the process." Perhaps CMOs do a better job of following this advice.

In addition to these explanations, there are other possibilities (though, without data, we can only speculate). For example, prior research finds that CMO principals are more likely than their district peers to (1) report that their schools define and enforce a comprehensive set of behavioral standards, and (2) require parents or students to sign an agreement acknowledging their responsibilities. So perhaps these common, schoolwide expectations around behavior help new teachers learn to manage their classrooms more quickly, allowing them to focus on their craft.

Or perhaps CMOs' practice of deploying a common curriculum makes it easier for their new teachers to improve. As our colleague Robert Pondiscio has written, a schoolwide curriculum fundamentally changes the nature of a teacher's job, especially if he or she is new to it. Rather than spending countless hours fumbling in the dark—or at least on the Internet—for instructional materials, she can spend that time studying lesson plans, building relationships with families, and offering feedback on student work. "Expecting teachers to be expert pedagogues and instructional designers," explains Pondiscio, "is one of the ways in which we push the job far beyond the abilities of mere mortals."

****

Each year, American schools hire approximately 200,000 new teachers. And because turnover rates have increased, 38 percent of K–12 teachers in the U.S. now have less than ten years of experience. These numbers surely make the case for doing more to retain great teachers, but they also show just how important it is that we help new teachers get better faster. As it turns out, accelerating teacher improvement is yet another area where all schools could take a page from the success of our nation's most effective charter school networks.

Introduction

Teachers are the most important school-specific determinant of student achievement, socioemotional development, and later-life outcomes.[2]
As teachers accumulate more experience in the profession, they tend to become more effective at improving these outcomes.[3] Yet teacher experience isn't uniformly distributed across American public schools. For example, teachers in the charter school sector have significantly less experience, on average, than those in traditional (i.e. district-operated) public schools,[4] meaning that students in many communities are exposed to teachers with different levels of experience depending on the school sector in which they are enrolled.

This much is known. What's not known—and what this study addresses—is whether teachers improve in the same ways and at the same rate as they gain experience in the schools of the two sectors. Enough is different about the school operations, funding levels, leadership, staffing arrangements, and teacher qualifications of charter and traditional public schools that it's important to focus on whether and how the effectiveness and improvement of their teachers may also differ. And because those qualities may also develop differently if teachers change schools (or careers), it's also important to look at teacher mobility across the two sectors.

This study examines the following questions:

1. How does teacher effectiveness vary across traditional and charter public schools? Within the charter sector, does teacher effectiveness differ by type of school (i.e. standalone versus networked)?

2. Is the trajectory of teacher effectiveness different in traditional public schools, standalone charter schools, and charter networks? (For example, do teachers improve more or less quickly in charter schools?)

3. How does teacher mobility vary across traditional and charter public schools? Are mobile teachers more (or less) effective than nonmobile teachers?

To address these questions, we use data from the Pennsylvania Department of Education (PDE) to compare the effectiveness, improvement, and mobility of teachers in traditional public schools and charters. We then refine our comparisons by distinguishing between two charter school types, charter management organizations (CMOs), which operate and manage multiple charter schools, and standalone charter schools. Although prior studies have examined whether school settings, including the poverty level and academic achievement of a school's students, are related to teacher effectiveness, ours is among the first to examine how teacher effectiveness and improvement differ between charter and traditional public schools, as well as within the charter sector.

Background

Like other studies, this one uses estimates of teachers' value-added—that is, their contribution to students' English language arts (ELA) and math achievement growth—as a proxy for their effectiveness. Although such estimates cannot capture other valuable aspects of teaching practice and behaviors,[5] research shows that (in addition to learning more math and English language arts) students assigned to teachers with higher value-added scores are more likely to go to college and earn higher salaries later in life.[6]

Prior research also suggests that teacher effectiveness improves rapidly during the early part of a teacher's career, up to approximately ten years of experience.[7] Yet this improvement is not uniform across teachers and schools. For example, Kraft and Papay show that variation in the returns to teaching experience across schools is explained, in part, by differences in schools' professional environments, while Sass et al. show that both the average effectiveness of and returns to experience for elementary school teachers are greater in the lowest-poverty schools in Florida and North Carolina than for teachers in the highest-poverty schools. Finally, Jackson and Bruegmann show that the effectiveness of North Carolina teachers in grades 3–5 improved more quickly—especially in their first years on the job—when their grade-level peers had at least four years of teaching experience.[8]

All of this suggests that, for any number of reasons, teachers in charter and traditional public schools could improve at different rates. After all, charter schools enroll a higher proportion of poor and minority students, and their teachers are, on average, younger, less experienced, less likely to hold advanced degrees, and less likely to be state certified than traditional public school (TPS) teachers.[9] Moreover, at least one study has found that few teacher candidates give equal weight to charter and traditional public schools when considering their initial teaching placements, suggesting that the two sectors attract different types of candidates.[10] And it's well known that teacher attrition rates are higher in charter schools.[11] For example, one Florida study found that charter school teachers were 18 percent more mobile than those working in district schools, even after controlling for school- and teacher-level characteristics.[12] And a more recent Massachusetts study found that charter teachers in the lowest and highest quintiles of effectiveness were more mobile than their district counterparts.[13]

Evidence on the relative effectiveness of teachers in charter and traditional public schools is mixed. For example, Cowen and Winters found that Florida teachers in charter elementary schools were less effective than TPS teachers, and Carruthers found that North Carolina teachers who move from traditional public schools to charters were less qualified and less effective than other mobile teachers.[14] However, a more recent working paper by Ozek et al. finds that charter school teachers in high-poverty Florida schools were more effective at raising student math achievement than their district counterparts in schools with similar levels of student poverty.[15] Finally, another recent paper by Cohodes et al. finds that teachers in Boston charter schools—like Boston charter schools themselves—are more effective in raising student achievement than their TPS counterparts in both ELA and math (though there is no difference in the rate at which charter and TPS teachers improve).[16]

Methodology

Data

Data on teachers and students who worked or enrolled in Pennsylvania's charter and traditional public schools between 2007–08 and 2016–17 come from the Pennsylvania Department of Education (PDE). For teachers, these data include information on individuals' demographic characteristics (including gender, race, and age), educational attainment and salary, and years of educational experience (in Pennsylvania public education). For students, the data include information on gender, race, age, free or reduced-price lunch (FRL) receipt, English language learner (ELL) status, special education (SPED) status (i.e., students with an individualized education plan), and gifted status. Because each teacher and student has a unique identifier, individual teachers and students can be linked for the purposes of constructing a measure of teacher effectiveness.

We observe student achievement outcomes—both scaled scores and proficiency levels for math and ELA—for all students in grades 3–8. For all analyses of student achievement and teacher effectiveness, we rely on math and ELA test scores from the Pennsylvania System of School Assessment (PSSA) for students in grades 3–8, which we standardize at the subject*grade*year level. From the student-level data, we also construct classroom- and school-level aggregates of student-level information, which include total enrollment, average age, and the proportions of students who were White, African American, Latino, Asian, FRL recipients, SPED, ELL, and gifted, as well as the proportion of students tested on the math and ELA portions of the state's end-of-year exams who were academically proficient.

Finally, we incorporate data from the U.S. Department of Education's Common Core of Data (CCD) to define two types of charter schools: (i) CMOs and (ii) standalone charter schools. CMOs are nonprofit organizations that operate multiple charter schools and often provide back-office functions or other forms of support to individual schools. Standalone charter schools operate independently, meaning they are not part of a larger management organization.

Sample

Our analytic sample includes grade 4–8 teachers who taught in just one school in a given school year. However, we exclude teachers who taught in virtual charter schools. We also drop any teachers for whom years of educational experience (in Pennsylvania public education) is listed as zero, and we code years of experience at a maximum of forty years. We further drop any teacher whose annual salary is less than $18,500 or greater than $200,000.[17] Finally, we retain only those teachers for whom a value-added measure (VAM) in math and/or ELA could be calculated.

Taking these steps leaves us with 142,752 teacher-year observations that are nested within 41,770 unique teachers and 2,493 public schools, including 2,341 traditional public schools (with 38,767 TPS teachers) and 152 charter schools (with 3,311 charter school teachers). See Appendix Table C1 for more detail on the teacher- and school-level characteristics of TPS and charter teachers in our analytic sample.

Measuring teacher effectiveness

Using student-teacher course links provided by the PDE, we construct a measure of fourth- through eighth-grade teachers' contributions to student achievement in math and ELA—that is, their test-based value-added. For each teacher-by-year observation, we calculate the average year-to-year change in student achievement for all tested students, controlling for characteristics that might be related to a teacher's effectiveness, including student demographics (age, race, and gender), grade level, FRL status, SPED status, ELL status, gifted status, and—importantly—baseline achievement (that is, achievement in the prior school year). In addition to controlling for these characteristics at the individual level, we also control for them at the classroom level (which allows us to control for peer effects), as well as at the school level.

We are able to estimate the value-added of teachers in grades 6–8 for all years (i.e., for 2008–09 through 2016–17). For grade 4–5 teachers, value-added can be calculated for the 2013–14 through 2016–17 school years. For more details, see *Appendix A*, which describes the statistical model for estimating teacher-level value-added scores in both math and ELA.

Addressing the research questions

Each question requires different methods to address (see *Appendix B* for more details).

Q1: How does teacher effectiveness vary across traditional and charter public schools? Within the charter sector, does teacher effectiveness differ by type of school (i.e. standalone versus networked)?

To address Q1, we first compare the average value-added of teachers in charter and traditional public schools in ELA and math. We further compare the effectiveness of charter and TPS teachers in schools with similar student populations based on (i) the share of a school's students receiving FRL; (ii) the share of a school's students who are racial/ethnic minorities; and (iii) the proportion of a school's students who are academically proficient. We then repeat each of these comparisons for teachers in CMOs and standalone charter schools, relative to the effectiveness of TPS teachers.

Q2: Is the trajectory of teacher effectiveness different in traditional public schools, standalone charter schools, and charter networks? (For example, do teachers improve more or less quickly in charter schools?)

To address Q2, we estimate regressions that include grade-by-year fixed effects, thus restricting our comparisons to teachers in the same year and grade. We also include teacher and school fixed effects, thus controlling for any time-invariant differences between teachers (such as ability and motivation), as well as schools (such as the nonrandom sorting of teachers and students). Finally, our preferred specification also includes teacher-by-school fixed effects, meaning we're only estimating the within-teacher returns to experience within school settings (and not conflating the returns to experience with any changes in effectiveness that may occur when teachers switch schools).

In addition to estimating the within-teacher returns to experience for all Pennsylvania public school teachers, we estimate them for teachers in each sector (i.e., traditional and charter), for teachers in CMOs, and for teachers in standalone charters. In the process, we also examine differences between charter and TPS teachers with the same years of teaching experience. Finally, we explicitly test for differential returns to experience between sectors, as well as within the charter sector (i.e., CMO versus standalone teachers).

Q3: How does teacher mobility vary across traditional and charter public schools? Are mobile teachers more (or less) effective than nonmobile teachers?

To address Q3, we construct five teacher-mobility pathways that could occur at the end of the school year, including those where teachers move to another school in the district or another district altogether (see *Mobility Pathways*). We then calculate the average mobility rates of teachers across the study period, by sector and by teacher-mobility type. We then compare the effectiveness of teachers who experience each mobility type to the effectiveness of nonmobile teachers in the same sector. Finally, we examine the professional pathways of teachers who exit the classroom but remain in public education in Pennsylvania.

Limitations

This study has at least two important limitations.

First, although it has contributed much to our understanding of teacher effectiveness, prior research suggests that test-based value-added is weakly correlated with other measures of teacher performance, such as classroom observation scores or student evaluations.[18] Incorporating such measures would provide a more comprehensive picture of how teachers improve within and across standalone charters, CMO-run schools, and traditional public schools, but those data are not available.

Second, because differences between school sectors could lead to selection on unobservable characteristics of teachers and students, we cannot definitely conclude that teachers in one sector are more effective than teachers in the other or that differential improvement rates are attributable to differences in human capital policies (as opposed to teachers' innate characteristics). In other words, observed differences in teacher effectiveness and improvement likely reflect both differences in human capital and differences in the school settings to which teachers are exposed.

Mobility pathways

We calculate five types of mobility:

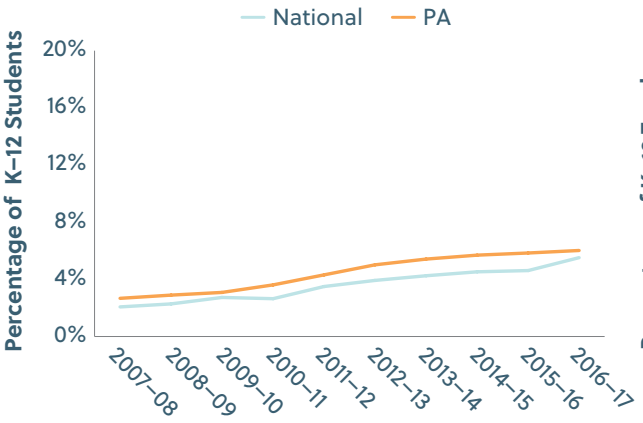
1. *Interdistrict mobility,* which includes any teachers who exited their geographic school district at the end of the academic year to teach in another Pennsylvania school district in the next academic year
2. *Intradistrict mobility*, which includes teachers who exited their school at the end of the academic year but remained in the same geographic school district as a teacher in the next academic year
3. *Intraschool mobility*, which includes teachers who taught a new subject or grade within the same school in the next academic year
4. *Role mobility*, which includes teachers who remained in Pennsylvania public education but assumed another educational role (i.e., principal, assistant principal, or instructional supervisor)
5. *Exit PA*, which includes teachers who exited public education in Pennsylvania.

Why Pennsylvania?

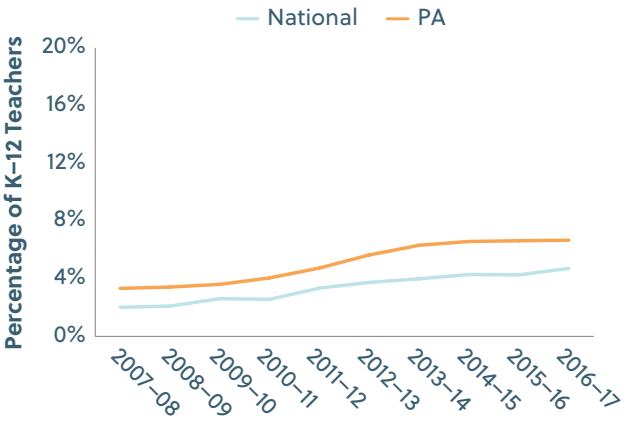
Pennsylvania is an ideal setting for investigating teacher effectiveness and mobility across the charter and traditional sectors. First, charter sector growth in Pennsylvania over the last ten years mirrors national trends, in terms of its share of K–12 public school students (Figure 1, Panel A) and teachers (Figure 1, Panel B). Second, the state contains a robust and growing supply of both CMOs and standalone charter schools (Figure 1, Panels C and D). Of the 165 brick-and-mortar charter schools in Pennsylvania during the 2016–17 school year, 115 were standalone charters and fifty were managed by one of the state's eleven CMOs.

Figure 1. Charter school market share in the United States vs. Pennsylvania

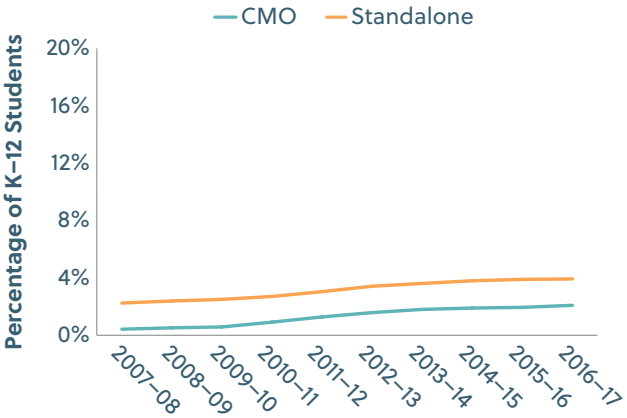
Panel A. Percentage of K–12 Students in Charter Schools



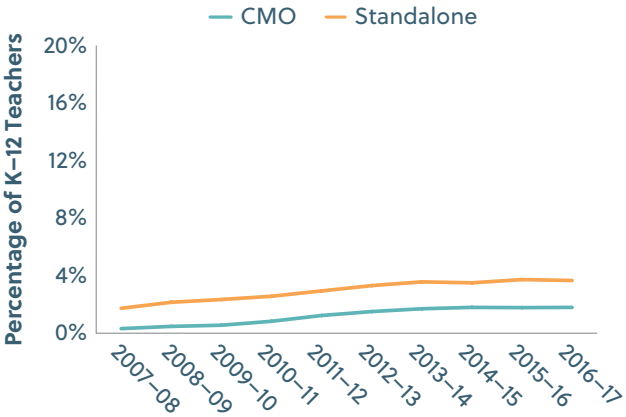
Panel B. Percentage of K–12 Teachers in Charter Schools



Panel C. Percentage of K–12 Pennsylvania Students in CMO or Standalone Charter Schools



Panel D. Percentage of K–12 Pennsylvania Teachers in CMO or Standalone Charter Schools



Notes. The figure shows the percentage of K–12 students (Panel A) or K–12 teachers (Panel B) in charter schools. Panels C and D show the percentage of K–12 students (Panel C) or K–12 teachers (Panel D) in Pennsylvania, by charter school type. National includes all states and the District of Columbia, excluding Pennsylvania. Charter school enrollment excludes virtual or cyber charter schools. Panels A and B use data from the Common Core of Data (CCD). Panels C and D use restricted-use data provided by the Pennsylvania Department of Education.

Findings

Finding #1: On average, teachers in Pennsylvania's charter schools are more effective in ELA but less effective in math than their peers in traditional public schools, though teachers in CMO-run schools are more effective in both subjects.

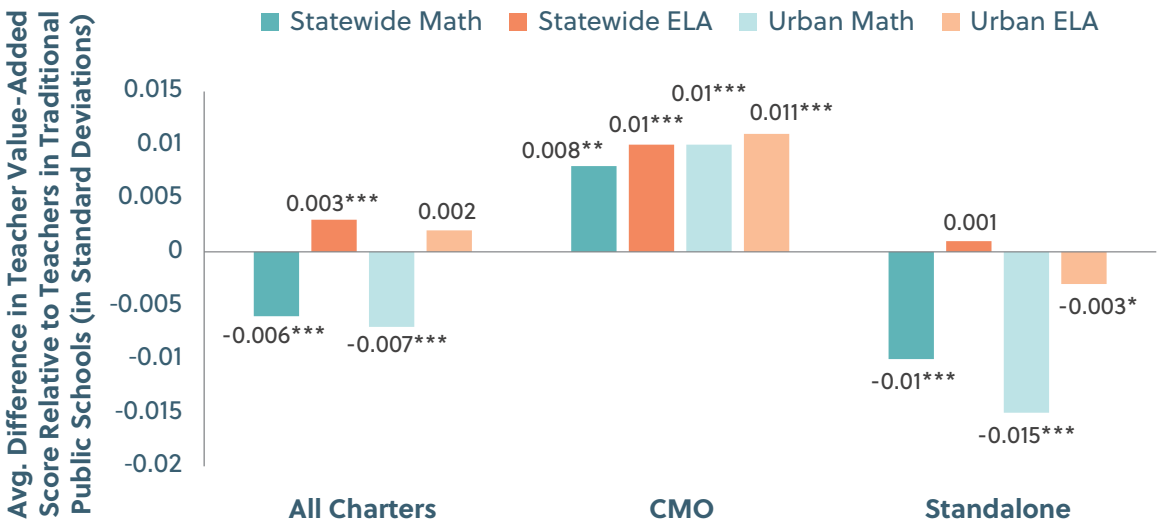
On average, teachers in Pennsylvania charter schools are more effective than teachers in traditional public schools in ELA but less effective in math (Figure 2). Specifically, charter teacher effectiveness is 0.006 student-level standard deviations lower in math and 0.003 student-level standard deviations higher in ELA (see Appendix Figure C1 for the distribution of teacher effectiveness by sector and subject).

These differences are modest. On average, 0.006 standard deviations in math translates to approximately two additional days of learning per year for students in traditional public schools (based on a 180-day school year in Pennsylvania), while 0.003 standard deviations in ELA translates to approximately 1.5 additional days of student learning per year for students in charter schools.[19] Yet comparisons between charter and traditional public schools mask important differences in teacher effectiveness within the charter school sector—and, in particular, between teachers in standalone and CMO-run schools.

On average, CMO teachers are 0.008 standard deviations more effective than those in traditional public schools in math and 0.010 standard deviations more effective in ELA (which translates to approximately three additional days of learning in math and five additional days of learning in ELA). In contrast, teachers in standalone charter schools are less effective—at least in math, where the estimates imply a loss of approximately four days of learning per year relative to teachers in traditional public schools and approximately seven days of learning per year relative to teachers in CMO-run schools.

Notably, these patterns hold when we restrict analysis to schools in urban communities, where approximately two-thirds of Pennsylvania's charter teachers are located (Appendix Table C2, Panels C and D), and when we control for various school-level characteristics, such as the proportion of students receiving FRL, the proportion of minority students, and the proportion of students scoring proficient on state standardized exam (Appendix Table C3).[20]

Figure 2. On average, teachers in CMO-run schools are more effective than teachers in traditional public schools, while teachers in standalone charters are less effective.



Notes. Regression-adjusted mean differences reported (net of year fixed effects) are based on results summarized in Appendix Table C2. Charter refers to the mean difference in teacher value-added for charter school teachers relative to TPS teachers. CMO refers to the mean difference in teacher value-added for charter school teachers in a CMO relative to TPS teachers. Standalone refers to the mean difference in teacher value-added for charter school teachers in standalone charter schools relative to TPS teachers. Regression-adjusted mean differences are statistically significant at *10 percent, **5 percent, and ***1 percent levels.

How do our findings compare to CREDO's results?

Our estimates of charter school teachers' relative effectiveness in urban locations differ from prior research by the Center for Research on Education Outcomes (CREDO), which has found generally mediocre performance for Pennsylvania's broader charter sector but more positive results for Philadelphia (where the vast majority of urban charters are located).[21]

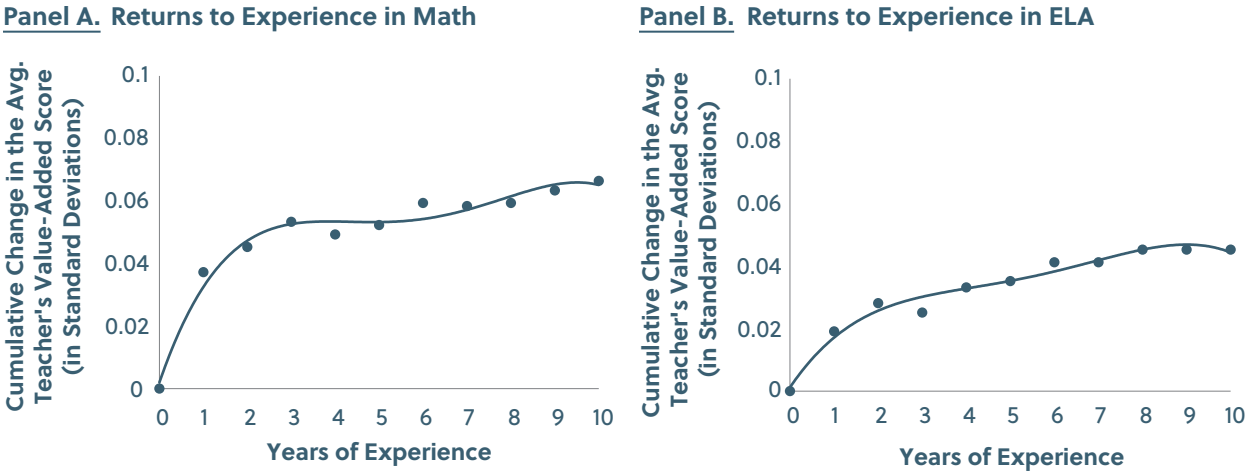
Two factors may explain these differences. First, because the goal of this report is to understand the evolution of individual teachers' effectiveness over time, our sample includes teachers who taught during the 2008–09 through 2016–17 academic years, while CREDO's 2019 report spans the 2013–14 through 2016–17 academic years.

Second, CREDO's estimates rely on an approach that matches otherwise similar students in charter and traditional schools (based on student demographics and achievement), whereas this report relies on estimates of *teacher* value-added, which don't necessarily sum to *school* value-added (even with identical data) because of how the underlying models work. In particular, school value-added conflates all school-specific factors (such as teachers, support staff, and leadership) that may be related to student achievement growth. In contrast, teacher value-added estimates a teacher's unique contribution to student achievement growth.

Finding #2: Like teachers elsewhere, teachers in Pennsylvania become more effective as they gain experience, but teachers in the state's CMOs improve more rapidly than teachers in its traditional public schools or standalone charters.

Like teachers in other parts of the country, teachers in Pennsylvania become more effective as they gain experience (Appendix Table C4). More specifically, they improve rapidly during the first five years of a their career—especially in math—and more slowly over the next five years (Figure 3). Notably, there are few additional returns to experience beyond ten years (Appendix Figure C2), consistent with prior research on the returns to teacher experience.[22]

Figure 3. On average, teachers become more effective as they gain experience, particularly in their first few years on the job.



Notes. Each panel presents nonparametric results censored at ten years of teacher experience with a fitted quartic function overlaid on the nonparametric estimates. All regressions include grade*year and teacher*school fixed effects, up to a cubic term of lagged achievement, both in the same subject (math or ELA) and off-subject; student-level controls (see *Methodology*); class-level controls, which are student-level controls aggregated to the classroom level, including lagged student achievement aggregated to the classroom level; and school-level controls, which are student-level controls aggregated to the school-level, including lagged student achievement aggregated to the school level. See Appendix Table C7 for point estimates upon which these figures are based.

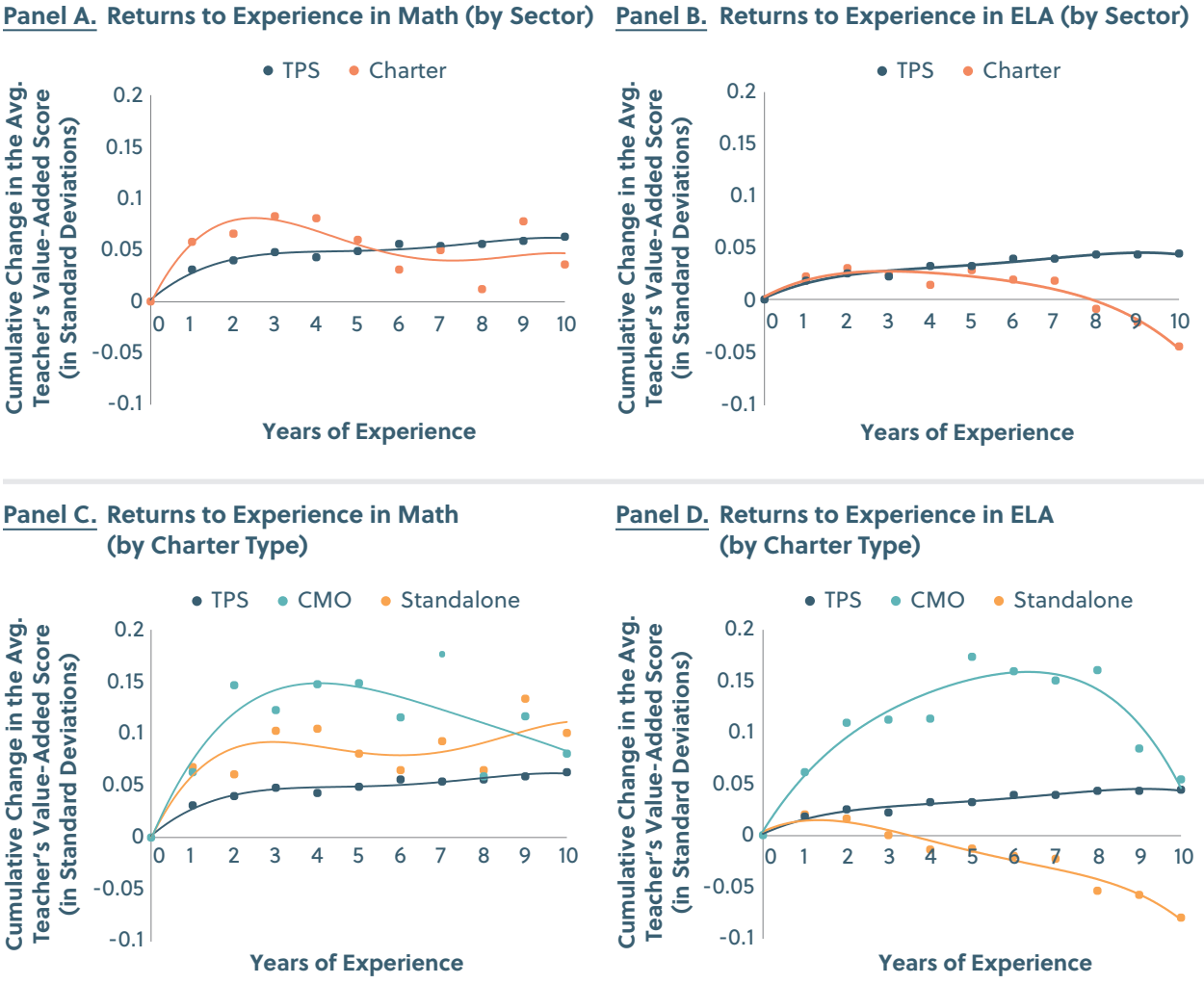
Because the average charter school teacher in Pennsylvania has six years of teaching experience, while the average TPS teacher has thirteen years of teaching experience (Figure 5, panels A and B), it seems likely that differences in experience explain some of the differences between sectors. And in fact, the gap between charter and TPS teachers' math performance becomes more modest once we control for experience (Appendix Table C4). However, teachers in CMO-run schools are also slightly less experienced, on average, than those in standalone charters (Figure 5, panels C and D). So what explains the higher value-added of teachers in CMO-run schools?

Part of the answer is that CMO teachers are more effective, on average, at the beginning of their teaching careers (Appendix Tables C5 and C6). Specifically, novice CMO teachers—those in their first year of teaching in Pennsylvania—are 0.009 standard deviations more

effective than novice TPS teachers in ELA. And the equivalent estimate for math (0.007 standard deviations) is also positive (though statistically insignificant). In contrast, novice standalone charter teachers are less effective in math than novice TPS teachers.

As illustrated in Figure 4, however, teacher effectiveness also grows more quickly in charter schools than it does in traditional public schools—at least in math.[23] Moreover, as illustrated in Panels C and D, teacher effectiveness in both subjects grows *far* more quickly in CMOs (though not in standalone charters).[24]

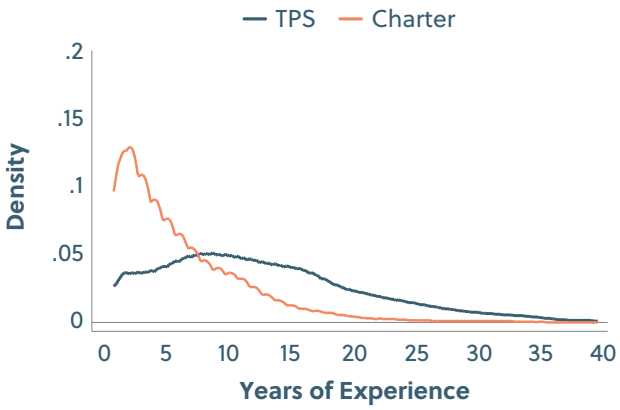
Figure 4. Teacher effectiveness improves more quickly in CMOs than in standalone charters or traditional public schools, particularly in ELA.



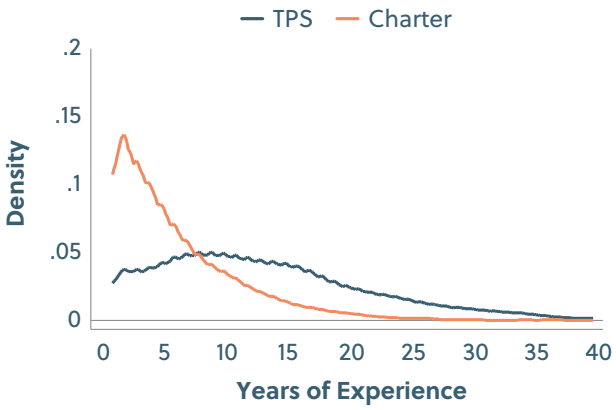
Notes. Each panel presents nonparametric estimates of the returns to experience (years of experience censored at ten years) with a fitted quartic function overlaid on the nonparametric estimates. All regressions include grade*year and teacher*school fixed effects, up to a cubic term of lagged achievement, both in the same subject (math or ELA) and off-subject; student-level controls (see *Methodology*); class-level controls, which are student-level controls aggregated to the classroom level, including lagged student achievement aggregated to the classroom level; and school-level controls, which are student-level controls aggregated to the school level, including lagged student achievement aggregated to the school level. See Appendix Table C8 for point estimates upon which these figures are based and Appendix Table C9 which presents statistical tests of the year-specific returns to experience estimates across and within sectors.

Figure 5. On average, teachers in charter schools are far less experienced than teachers in traditional public schools.

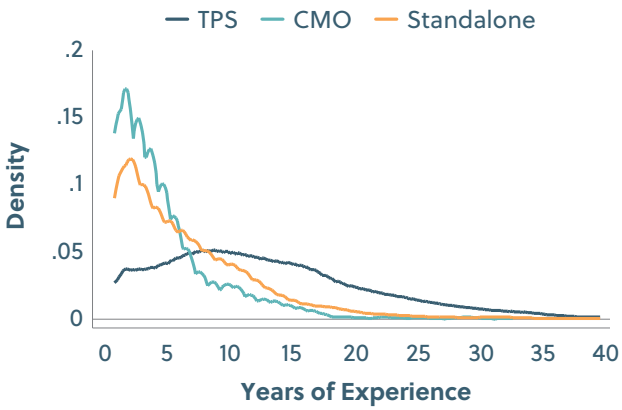
Panel A. Distribution of Teaching Experience in Math (By Sector)



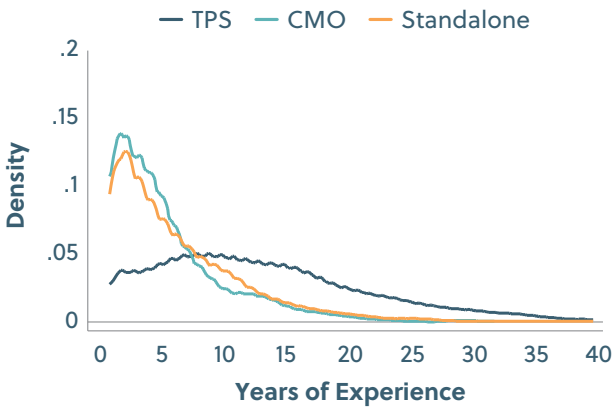
Panel B. Distribution of Teaching Experience in ELA (By Sector)



Panel C. Distribution of Teaching Experience in Math (By Charter Type)



Panel D. Distribution of Teaching Experience in ELA (By Charter Type)

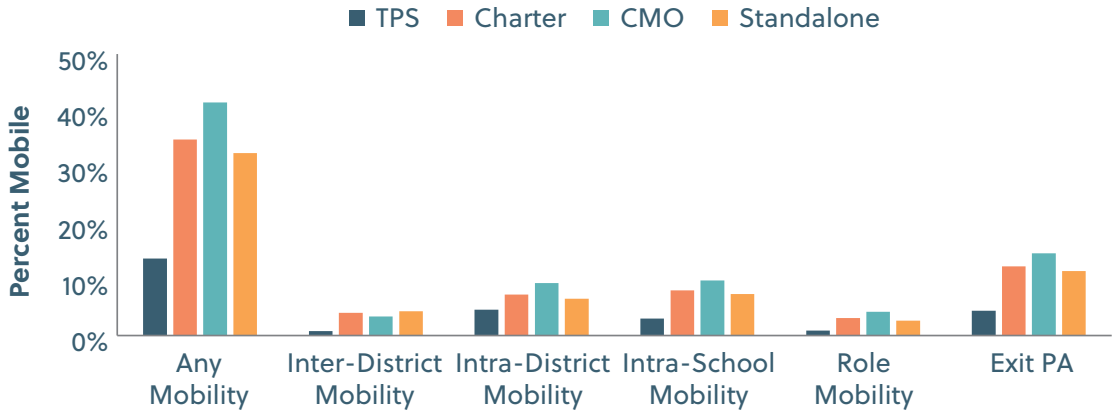


Notes. Sample includes all full-time teachers with math or ELA value-added (VAM) who taught in K–12 Pennsylvania public schools in any school year between 2008–09 and 2016–17. In Panel A, mean experience among teachers with math value-added is 13.1 years for TPS teachers and 6.2 years for charter teachers. In Panel B, mean experience among teachers with ELA value-added is 13.3 years for TPS teachers and 6.1 years for charter teachers. In Panel C, mean experience among teachers with math value-added is 4.8 years for CMO teachers and 6.6 years for standalone charter teachers. In Panel D, mean experience among teachers with ELA value-added is 5.5 years for CMO teachers and 6.3 years for standalone charter teachers.

Finding #3: Pennsylvania charter schools struggle with teacher retention, but CMOs retain and promote more effective teachers to school and instructional leadership positions.

Teachers in Pennsylvania charter schools are significantly more mobile than teachers in the state's traditional public schools (Figure 6). For example, 26.8 percent of charter teachers exited their schools annually, versus 10.6 percent of TPS teachers. Similarly, 34.8 percent of charter teachers experienced any mobility event at the end of the school year versus just 13.7 percent of teachers in traditional public schools[25] (in addition to changing schools, a mobility event also includes other forms of mobility, such as changing grades, subject, or roles within a school). Notably, mobility rates were particularly high in CMO-run schools, where 31.6 percent of teachers exited their schools and 41.4 percent experienced a mobility event.[26]

Figure 6. Pennsylvania's charter schools have higher teacher-mobility rates than the state's traditional public schools.



Notes. Each bar represents the percent of teachers who experienced a mobility event (by mobility type) at the end of the academic year (see *Mobility Pathways* on page 12 for definitions). See Appendix Table C10 for more detail on mobility types and statistical tests comparing mobility rates by sector and charter type.

Much of the difference in charter and traditional schools' total mobility rate is due to the fact that 12.3 percent of charter teachers (and 14.6 percent of CMO teachers) exit Pennsylvania education. However, charter teachers are also more likely to exit teaching for another professional role in Pennsylvania public education than TPS teachers—3.1 percent of charter teachers compared to 0.9 percent of TPS teachers. And this is particularly true of CMO teachers, 4.3 percent of whom move to another role.

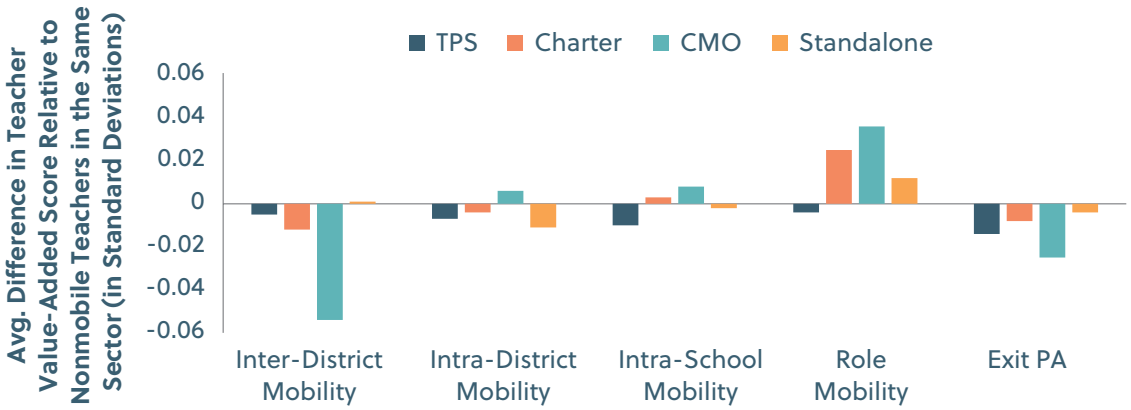
Per Figure 7, both charter and TPS teachers who exit public school teaching in Pennsylvania ("Exit PA") are significantly less effective in math and ELA than nonmobile teachers. However, CMO teachers who exit public education are particularly ineffective relative to nonmobile CMO teachers.

In contrast, charter teachers who exit teaching for another professional role in PA public education are significantly more effective (in math) than nonmobile charter teachers, while TPS teachers who move to another role are no more or less effective than nonmobile TPS teachers.

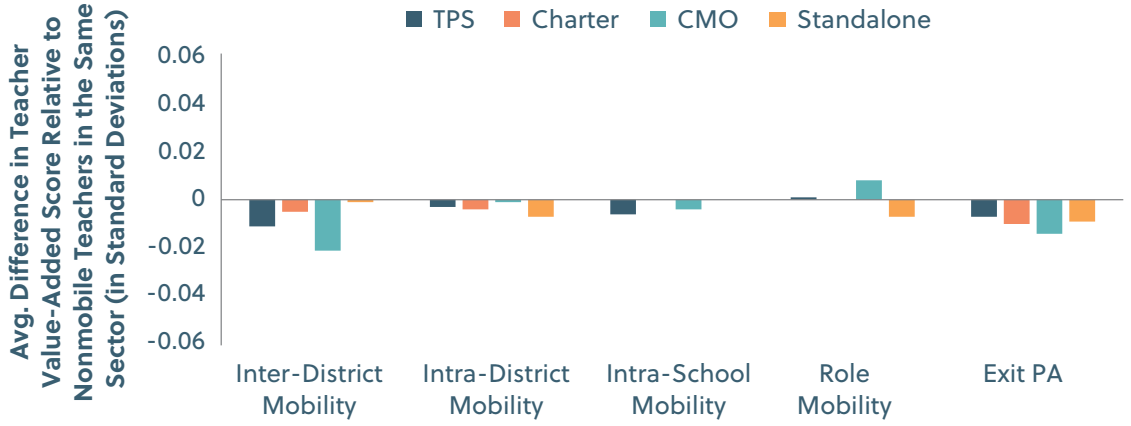
Once again, this difference is being driven by teacher mobility in CMO-run schools.

Figure 7. In general, mobile teachers are less effective than nonmobile teachers, but CMO teachers who are highly effective are often promoted to nonteaching roles.

Panel A. Math



Panel B. ELA



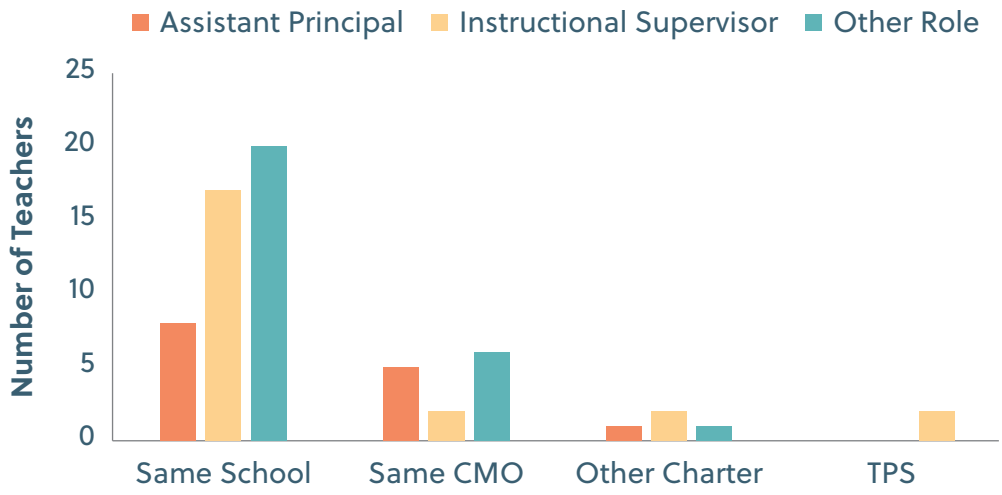
Notes. Regression-adjusted mean differences reported (net of year fixed effects) are based on results summarized in Appendix Table C11. TPS estimate is the mean difference in teacher value-added (VAM) for TPS teachers (by type of mobility) relative to nonmobile TPS teachers. Charter estimate is the mean difference in teacher value-added for charter school teachers (by type of mobility) relative to nonmobile charter teachers. CMO estimate is the mean difference in teacher value-added for CMO teachers (by type of mobility) relative to nonmobile CMO teachers. Standalone estimate is the mean difference in teacher value-added for standalone charter school teachers (by type of mobility) relative to nonmobile teachers in standalone charter schools.

So where do these highly effective teachers end up in the following school year? Of the 173 charter school teachers in our sample who exited teaching for another professional role in Pennsylvania public education, 126 (72.8 percent) remained in the same school, thirty-five (20.2 percent) moved to a different charter school, and twelve (6.9 percent) moved to a traditional public school.

Similarly, of the sixty-four teachers in CMO-run schools who exited teaching for another professional role, forty-five (70 percent) remained in the same school (Figure 8). However, another thirteen (or 20 percent) moved to another school within the same CMO, four (6.2 percent) moved to a charter school outside of their CMO, and just two (3.1 percent) entered a traditional public school. In other words, CMOs actually kept 90 percent of "role switchers" within their organizations—though not necessarily in the same school.

Notably, of the CMO teachers who remained in the same school or the same CMO, thirty-two (or 55 percent) were promoted to leadership positions, such as assistant principal or instructional supervisor (for example, math or literacy coach), suggesting that charter schools strategically target highly effective teachers for promotion.

Figure 8. Many high-performing CMO teachers are promoted to leadership positions within their school or organization.



Notes. Each bar represents the number of "role mobile" CMO teachers who, within a school type in the next academic year, assumed one of four nonteaching positions: principal, assistant principal, instructional supervisor, or other. No teachers moved into the role of principal.

Implications

Overall, the results suggest that Pennsylvania's CMOs are succeeding with a fundamentally different approach to human capital than the state's traditional public schools—an approach that relies heavily on recruitment, development, and promotion to drive improvements in student-achievement outcomes.

First, novice CMO teachers are more effective, on average, than novice teachers in traditional public schools, perhaps reflecting efforts by CMOs to actively identify and recruit young and highly motivated individuals with relatively little teaching experience. Although this report does not address teacher-recruitment practices, the average novice CMO teacher in our sample was just twenty-seven years old, two years younger than the average novice in Pennsylvania's traditional public schools and standalone charters.

Second, the returns to teacher experience in the first five years are greatest for CMO teachers, suggesting that CMOs may be more effective at developing novice teachers (though this finding could also reflect the fact that novice teachers who are more effective improve more quickly). Notably, prior evidence does suggest that CMOs invest in the development of their novice teachers via intensive observation and feedback by instructional coaches and school leadership,[27] which other research suggests can improve teacher practice and student achievement.[28]

Third, the development of teacher human capital in CMOs may be accelerated or enhanced by the strategic retention and promotion of more effective teachers to positions of school and instructional leadership.

Finally, although teachers in CMOs exit public education at higher rates than teachers in traditional public schools or standalone charter schools, those who do exit are among the least effective.

Collectively, these findings suggest that greater attention should be paid to the human capital policies and practices implemented by charter schools in general and CMOs in particular. Indeed, a key feature of the charter school model is greater autonomy around human capital policies than traditional public schools. Thus, sectoral differences in the effectiveness of novice teachers, their professional development and growth, as well as their

promotion and retention are likely explained by differences in these policies and practices. Additional work should be done to better understand the labor pool from which CMOs and traditional public schools recruit and the extent to which successful teacher recruitment, development, and promotion practices implemented by CMOs can inform the human capital strategies pursued by traditional public schools.

Appendix A: Measuring teacher effectiveness

We measure teacher effectiveness based on a teacher's value-added contribution to student achievement. Following prior work by Kraft (2019), we estimate teacher effectiveness using a restricted maximum likelihood approach. This random-effects framework generates the empirical Bayes estimator, which shrinks less precise teacher effects toward their population mean (for example, teacher effects will be less precise when the estimated teacher effects are based on fewer students). We specify the model as the following:

$$\text{(A1) } Achievement_{ijst} = \beta_1 Ach_{ijs(t-1)} + \beta_2 Ach^{other}_{ijs(t-1)} + \beta_3 \mathbf{X_{it}} + \beta_4 \mathbf{C_{jt}} + \beta_5 \mathbf{Z_{st}} + \Omega_{jt} + \mu_{ijst}$$

where achievement for student *I* with teacher *j* at school *s* in year *t* is modeled as a function of a student's prior-year test score in the same subject ($Ach_{ijs(t-1)}$) and prior-year test score in the other subject ($Ach^{other}_{ijs(t-1)}$). For example, if we are estimating teacher value-added for teacher *j* in math in school year *t*, $Ach_{ijs(t-1)}$ will be student *i*'s math test score from the prior school year and $Ach^{other}_{ijs(t-1)}$ will be student *i*'s ELA test score from the prior school year. **X** is a vector of time-varying student characteristics, including age, race, gender, grade level, FRL eligibility status, SPED status, ELL status, and gifted status. **C** is a vector of time-varying classroom characteristics, which are the student characteristics aggregated to the classroom level. And **Z** is a vector of time-varying school characteristics, which are the student characteristics aggregated to the school-level. The parameter estimate $\hat{\Omega}_{jt}$ is the teacher-by-year random effect, capturing teacher *j*'s estimated value-added contribution to student achievement (in either math or ELA) in school year *t*. Because we model teacher effectiveness as a function of lagged student test scores, teacher-effectiveness measures are available for grade 4–8 teachers.

Appendix B: Statistical methods

To address the second research question, we follow prior work on teacher productivity (Kraft & Papay, 2014; Papay & Kraft, 2015; and Rockoff, 2004) and estimate variants of the following education production function:

$$\text{(B1) } A_{it} = \alpha(g(A_{i,t-1})) + \beta(f(Experience_{jt})) + \mathbf{X_{it}}\Gamma + \mathbf{C_{jt}}\Phi + \mathbf{Z_{st}}\Omega + \lambda_{gt} + \theta_s + \delta_j + \varepsilon_{igjst}$$

where A_{it} is the test score of student *I* at the end of school year *t* on the PSSA mathematics or ELA exam and A_{it-1} is student *i*'s prior-year test score in both math and ELA.[29] We include up to a cubic function of prior achievement (A_{it-1}). We standardize all test scores at the subject-grade-year level to have mean zero (and standard deviation one). **X** is a vector of time-varying student characteristics, including age, race, gender, grade level, FRL status (that is, receipt), SPED status, ELL status, and gifted status. **C** is a vector of time-varying classroom characteristics, which are the student characteristics aggregated to the classroom level, as well as the mean prior-year class achievement in math and ELA. And **Z** is a vector of time-varying school characteristics, which are the student characteristics aggregated to the school level, as well as the mean prior-year school achievement in math and ELA. The variable Φ represents a school fixed effect, accounting for all time-invariant school-level characteristics; λ is a grade-by-year fixed effect that accounts for annual educational shocks common to all students in the same grade and school year; δ is a teacher fixed effect; and ε is a mean-zero random-error term. Our preferred specification of equation (B1) includes a full set of teacher-by-school fixed effects, thus mitigating the concern that the estimated returns to experience are conflated by nonrandom teacher transitions across schools.

β is the parameter of interest. In our preferred specification, we model experience nonparametrically via the inclusion of year-specific indicator variables. In this approach, β will estimate year-specific returns to experience rather than a mean return to experience gradient across all years of experience. We cluster standard errors at the grade-year-school level. We estimate equation (B1) separately by sector (charter or traditional public school) and by charter school type (CMO or standalone).

Due to collinearity issues that arise when estimating returns to experience and grade-by-year effects within a teacher cell, we impose the additional assumption that the returns to teacher experience are constant after ten years of experience. Empirically, this means

we censor years of experience at ten for teachers with ten or more years of experience. This approach allows us to simultaneously identify grade-by-year effects from teacher observations with ten or more years of experience and recover returns to experience for teachers with fewer than ten years of experience.[30] In the case that we observe significant returns to experience after ten years, this approach would downwardly bias our estimates for returns to teacher experience (Papay & Kraft, 2015). To test this assumption, we also estimate models that censor years of experience at fifteen and twenty years; these results provide evidence that teacher returns to experience in our data are effectively constant after ten years of experience (see Appendix Figure C2 and Appendix Table C7).

Finally, we estimate whether the returns to teacher experience profile varies by sector (that is, charter and TPS) by amending equation (1) as follows:

$$(B2)\ A_{it} = \alpha(g(A_{i,t-1})) + \beta(f(Experience_{jt}) + \gamma(f(Experience_{jt} * Charter_s) + \mathbf{X_{it}\Gamma} + \mathbf{C_{jt}\Phi} + \mathbf{Z_{st}\Omega} + \lambda_{gt} + \theta_s + \delta_j + \varepsilon_{igjst}$$

In equation (B2), we interact an indicator for whether a teacher teaches in a charter school with teacher experience. As with equation (B1), we estimate the returns to experience gradient nonparametrically by including year-specific indicator variables (up to ten years); thus, γ estimates the differential returns to experience for charter school teachers relative to their TPS counterparts for each of (up to) ten years of teaching experience. Moreover, following prior work on the labor-market returns to experience and education (Carlsen et al., 2016), we also interact the charter indicator with all other variables in the model. This enables statistical testing of the coefficients, allowing insight into whether there are differential year-specific returns to experience by sector. All other variables are defined as in equation (1), and standard errors are clustered at the grade-year-school level.

In alternative estimates of equation (B2), we compare the year-specific returns to experience between CMO and TPS teachers by replacing the charter indicator with an indicator for whether a teacher teaches in a CMO school (and restricting the estimating sample to teachers in traditional public schools and CMOs). We also compare the year-specific returns to experience between standalone and TPS teachers by replacing the charter indicator with an indicator for whether a teacher teaches in a standalone school (and restricting the estimating sample to teachers in traditional public schools and standalone schools). Finally, we compare the year-specific returns to experience between standalone and CMO teachers by replacing the charter indicator with an indicator for whether a teacher teaches in a CMO school (and restricting the estimating sample to teachers in CMO and standalone schools).

Appendix C: Supplemental tables and figures

Table C1. Teacher and school characteristics, by sector

	All	TPS	Charter	CMO	Standalone
Panel A. Teacher characteristics					
Age	40.56 (10.36)	40.91 (10.29)	33.52*** (9.18)	31.32*** (7.22)	34.36 (9.70)
Female	0.77	0.77	0.78**	0.79	0.78
White	0.94	0.95	0.80***	0.70***	0.83
Black	0.04	0.04	0.15***	0.20***	0.13
Hispanic	0.01	0.01	0.02***	0.04***	0.02
Other race	0.00	0.00	0.01***	0.03***	0.01
Experience	12.88 (8.34)	13.22 (8.32)	6.11*** (5.36)	5.16*** (4.41)	6.47 (5.64)
Advanced degree	0.55	0.55	0.40***	0.36***	0.41
Salary	65,599.39 (17,256.74)	66,380.36 (17,148.34)	50,126.47*** (10,963.90)	54,835.20*** (11,242.47)	48,324.99 (10,302.19)
Elementary	0.18	0.19	0.02***	0.00***	0.03
Middle	0.37	0.39	0.01***	0.02***	0.01
Elem/middle	0.32	0.31	0.51***	0.68***	0.44
Nontraditional	0.13	0.12	0.46***	0.29***	0.52
City	0.19	0.16	0.69***	0.85***	0.63
Suburban	0.49	0.50	0.25***	0.15***	0.29
Rural	0.22	0.23	0.04***	0.00***	0.06
Town	0.10	0.11	0.02***	0.00***	0.02

cont. on next page...

	All	TPS	Charter	CMO	Standalone
Panel B. School characteristics					
Enrollment	703.22 (346.08)	691.30 (308.88)	939.31*** (737.54)	772.04*** (311.27)	1,003.31 (833.87)
Female	0.49 (0.03)	0.49 (0.03)	0.51*** (0.06)	0.49*** (0.03)	0.51 (0.07)
Age	11.25 (2.22)	11.27 (2.22)	10.94*** (2.14)	10.98 (2.00)	10.92 (2.19)
White	0.70 (0.30)	0.72 (0.29)	0.26*** (0.32)	0.13*** (0.23)	0.31 (0.34)
Minority	0.24 (0.29)	0.21 (0.27)	0.67*** (0.35)	0.81*** (0.25)	0.62 (0.37)
FRPL	0.44 (0.27)	0.43 (0.27)	0.65*** (0.30)	0.80*** (0.21)	0.59 (0.31)
IEP	0.17 (0.05)	0.17 (0.05)	0.17** (0.07)	0.19*** (0.05)	0.16 (0.08)
ELL	0.03 (0.05)	0.03 (0.05)	0.04*** (0.07)	0.05*** (0.08)	0.04 (0.06)
Gifted	0.04 (0.05)	0.05 (0.05)	0.00*** (0.01)	0.00*** (0.02)	0.00 (0.02)
Math proficiency	0.58 (0.24)	0.59 (0.24)	0.39*** (0.25)	0.35*** (0.25)	0.41 (0.25)
ELA proficiency	0.66 (0.19)	0.67 (0.18)	0.49*** (0.21)	0.43*** (0.18)	0.52 (0.21)
Teachers	41,770	38,767	3,311	1,050	2,384
Schools	2,493	2,341	152	43	115
Teacher*years	142,752	135,893	6,859	1,898	4,961

Notes. In Panel A, proportions are reported, except for age and experience, which report means (standard deviation). In Panel B, school-level means (standard deviation), weighted by teacher counts, are reported. Sample includes all full-time teachers teaching in K–12 Pennsylvania public schools in any school year during the 2008–09 through the 2016–17 school years. Advanced degree includes a master's and/or doctorate degree. Experience is the total number of years of educational service in Pennsylvania. Salary is inflation adjusted ($2016). Elementary schools enroll students in grades K–5, middle schools enroll students in grades 6–8, elem/middle schools enroll students in grades K–8 who are not otherwise enrolled in an elementary or middle school, and nontraditional schools enroll students in all other grade spans. CMO schools are charter schools that are managed by a CMO with more than one school in a year. Standalone schools are charter schools without oversight from a CMO. Because schools can change CMO/standalone status across school years (that is, standalone charter schools can become CMO-managed charter schools), the count of CMO and standalone schools does not equal the unique count of charter schools. The differences between teachers in traditional public schools and charter schools (reported in the "all charter school" column) and differences between teachers in CMO and standalone charter schools (reported in the "CMO" column) are statistically significant at *10 percent, **5 percent, and ***1 percent levels.

Table C2. Difference in effectiveness of charter and TPS teachers

	Math VAM			
	(1)	(2)	(3)	(4)
Panel A. All charters				
Charter	-.006*** (.0016)	-.006*** (.0016)	-.009*** (.0018)	-.010*** (.0018)
R^2	.0002	.0073	.0493	.1433
Panel B. Charter type				
Standalone	-.010*** (.0017)	-.010*** (.0017)	-.014*** (.0020)	-.015*** (.0020)
CMO	.007** (.0036)	.008** (.0036)	.004 (.0036)	.003 (.0038)
R^2	.0006	.0077	.0497	.1437
P-value from F-test: *CMO=Standalone*	.0000	.0000	.0000	.0000
Teacher*years	83,372			
Teachers	27,718			
Schools	2,488			
Panel C. All urban charters				
Charter	-.007*** (.0021)	-.007*** (.0021)	-.009*** (.0022)	-.009*** (.0022)
R^2	.0008	.0196	.0291	.0645
Panel D. Urban charter type				
Standalone	-.015*** (.0024)	-.015*** (.0024)	-.016*** (.0024)	-.017*** (.0025)
CMO	.010*** (.0039)	.010*** (.0040)	.007* (.0041)	.007* (.0041)
R^2	.0036	.0224	.0314	.0670
P-value from F-test: CMO=Standalone	.0000	.0000	.0000	.0000
Teacher*years	16,572			
Teachers	6,722			
Schools	551			
Year FE		X	X	
District FE			X	
District*year FE				X

cont. on next page...

	ELA VAM			
	(5)	(6)	(7)	(8)
Panel A. All charters				
Charter	.003*** (.0010)	.003*** (.0010)	.001 (.0011)	.000 (.0012)
R^2	.0001	.0033	.0542	.1705
Panel B. Charter type				
Standalone	.001 (.0012)	.001 (.0012)	-.001 (.0013)	-.002 (.0013)
CMO	.009*** (.0021)	.010*** (.0021)	.007*** (.0021)	.006*** (.0022)
R^2	.0003	.0035	.0543	.1706
P-value from F-test: *CMO=Standalone*	.0001	.0001	.0024	.0015
Teacher*years	97,925			
Teachers	32,326			
Schools	2,488			
Panel C. All urban charters				
Charter	.002* (.0013)	.002 (.0013)	.000 (.0014)	.000 (.0014)
R^2	.0002	.0183	.0391	.0685
Panel D. Urban charter type				
Standalone	-.002 (.0016)	-.003* (.0016)	-.004** (.0016)	-.004** (.0016)
CMO	.012*** (.0023)	.011*** (.0023)	.009*** (.0024)	.009*** (.0024)
R^2	.0023	.0202	.0425	.0702
P-value from F-test: CMO=Standalone	.0000	.0000	.0000	.0000
Teacher*years	18,099			
Teachers	7,340			
Schools	549			
Year FE		X	X	
District FE			X	
District*year FE				X

Notes. Each column (within a panel) is a separate regression. In Panels A and C, "charter" refers to the mean difference in teacher value-added (VAM) for charter school teachers relative to TPS teachers (coefficients reported with robust standard errors in parentheses). In Panels B and D, "CMO" refers to the mean difference in teacher value-added for charter school teachers in a CMO relative to TPS teachers (coefficients reported with robust standard errors in parentheses). "Standalone" refers to the mean difference in teacher value-added for charter school teachers in standalone charter schools relative to TPS teachers (coefficients reported with robust standard errors in parentheses). "District" is the geographic location of the TPS district (that is, the funding district) in which charter schools are located. In Panels A and B, the sample includes all full-time teachers teaching in K–12 Pennsylvania public schools in any school year during the 2008–09 through the 2016–17 school years. In Panels C and D, the sample includes all full-time teachers teaching in K–12 Pennsylvania public schools located in urban districts in any school year during the 2008–09 through the 2016–17 school years. The coefficients are statistically significant at *10 percent, **5 percent, and ***1 percent levels

Table C3. Difference in effectiveness of charter and TPS teachers, by school characteristics

School characteristic:	Math VAM			
	FRPL	Minority	Achievement	All
Panel A. All charters				
Charter	-.007*** (.002)	-.006*** (.002)	-.007*** (.002)	-.006*** (.002)
R^2	.008	.007	.008	.008
Panel B. Charter type				
Standalone	-.011*** (.002)	-.011*** (.002)	-.011*** (.002)	-.010*** (.002)
CMO	.017*** (.004)	.018*** (.004)	.017*** (.004)	.017*** (.004)
R^2	.008	.008	.008	.008
P-value from F-test: *CMO=standalone*	.0000	.0000	.0000	.0000
Teacher*years	83,372			
Teachers	27,718			
Schools	2,488			
Panel C. All urban charters				
Charter	-.007*** (.002)	-.006*** (.002)	-.006*** (.002)	-.007*** (.002)
R^2	.021	.020	.020	.022
Panel D. Urban charter type				
Standalone	-.016*** (.002)	-.014*** (.002)	-.014*** (.002)	-.015*** (.002)
CMO	.026*** (.005)	.025*** (.005)	.025*** (.005)	.026*** (.005)
R^2	.024	.023	.023	.025
P-value from F-test: *CMO=standalone*	.0000	.0000	.0000	.0000
Teacher*years	16,572			
Teachers	6,722			
Schools	551			

cont. on next page...

School characteristic:	ELA VAM			
	FRPL	Minority	Achievement	All
Panel A. All charters				
Charter	.002** (.001)	.003*** (.001)	.002 (.001)	.004*** (.001)
R^2	.003	.003	.004	.004
Panel B. Charter type				
Standalone	-.000 (.001)	.001 (.001)	-.001 (.001)	.001 (.001)
CMO	.009*** (.002)	.009*** (.002)	.008*** (.002)	.009*** (.002)
R^2	.004	.004	.004	.005
P-value from F-test: *CMO=standalone*	.0051	.0060	.0032	.0090
Teacher*years	97,925			
Teachers	32,326			
Schools	2,488			
Panel C. All urban charters				
Charter	.001 (.001)	.002 (.001)	.002 (.001)	.003** (.001)
R^2	.019	.018	.019	.021
Panel D. Urban charter type				
Standalone	-.003** (.002)	-.003* (.002)	-.002 (.002)	-.002 (.002)
CMO	.014*** (.003)	.014*** (.003)	.013*** (.003)	.014*** (.003)
R^2	.021	.020	.021	.023
P-value from F-test: *CMO=standalone*	.0000	.0000	.0000	.0000
Teacher*years	18,099			
Teachers	7,340			
Schools	549			

Notes. Each column (within a panel) is a separate regression. All regressions include year fixed effects. Each column controls for the school-level characteristic indicated in the column heading ("FRPL" is the proportion of a school's students receiving FRL, "minority" is the proportion of a school's students who are racial/ethnic minority, "achievement" is the proportion of a school's students who are academically proficient, and "all" indicates that the regression controls for all three of these school-level characteristics). In Panels A and C, "charter" refers to the mean difference in teacher value-added (VAM) for charter school teachers relative to TPS teachers (coefficients reported with robust standard errors in parentheses). In Panels B and D, "CMO" refers to the mean difference in teacher value-added for charter school teachers in a CMO relative to TPS teachers (coefficients reported with robust standard errors in parentheses). "Standalone" refers to the mean difference in teacher value-added for charter school teachers in standalone charter schools relative to TPS teachers (coefficients reported with robust standard errors in parentheses). "District" is the geographic location of the TPS district (that is, the funding district) in which charter schools are located. In Panels A and B, the sample includes all full-time teachers teaching in K–12 Pennsylvania public schools in any school year during the 2008–09 through the 2016–17 school years. In Panels C and D, the sample includes all full-time teachers teaching in K–12 Pennsylvania public schools located in urban districts in any school year during the 2008–09 through the 2016–17 school years. The coefficients are statistically significant at *10 percent, **5 percent, and ***1 percent levels.

Table C4. Association between teacher effectiveness and experience, by sector

	Math VAM			
	(1)	(2)	(3)	(4)
Panel A. All charters				
Charter	-.004*** (.0016)	-.004** (.0016)	-.007*** (.0018)	-.008*** (.0019)
Experience	.0007*** (.0001)	.0008*** (.0001)	.0010*** (.0001)	.0010*** (.0001)
Experience^2	-.00002*** (.0000)	-.00002*** (.0000)	-.00003*** (.0000)	-.00002*** (.0000)
R^2	.0006	.0079	.0500	.1441
Panel B. Charter type				
Standalone	-.009*** (.0018)	-.008*** (.0017)	-.012*** (.0020)	-.013*** (.0020)
CMO	.009** (.0036)	.010*** (.0036)	.006* (.0037)	.006 (.0038)
Experience	.0007*** (.0001)	.0009*** (.0001)	.0010*** (.0001)	.0011*** (.0001)
Experience^2	-.00002*** (.0000)	-.00002*** (.0000)	-.00002*** (.0000)	-.00003*** (.0000)
R^2	.0010	.0083	.0504	.1445
P-value from F-test: *CMO=Standalone*	.0000	.0000	.0000	.0000
Year FE		X	X	
District FE			X	
District*year FE				X
Teacher*years	83,372			
Teachers	27,718			
Schools	2,488			

cont. on next page...

	ELA VAM			
	(5)	(6)	(7)	(8)
Panel A. All charters				
Charter	.004*** (.0010)	.004*** (.0010)	.002* (.0012)	.001 (.0012)
Experience	.0003*** (.0001)	.0003*** (.0001)	.0003*** (.0001)	.0003*** (.0001)
Experience^2	-.00000** (.0000)	-.00000*** (.0000)	-.00000*** (.0000)	-.00000*** (.0000)
R^2	.0003	.0036	.0544	.1707
Panel B. Charter type				
Standalone	.001 (.0012)	.002 (.0012)	.000 (.0013)	-.001 (.0013)
CMO	.011*** (.0021)	.011*** (.0021)	.008*** (.0021)	.007*** (.0022)
Experience	.0003*** (.0001)	.0003*** (.0001)	.0003*** (.0001)	.0003*** (.0001)
Experience^2	-.00000** (.0000)	-.00000** (.0000)	-.00000** (.0000)	-.00000** (.0000)
R^2	.0005	.0038	.0545	.1708
P-value from F-test: *CMO=Standalone*	.0001	.0001	.0020	.0012
Year FE		X	X	
District FE			X	
District*year FE				X
Teacher*years	97,925			
Teachers	32,326			
Schools	2,488			

Notes. Each column is a separate regression (coefficients reported with robust standard errors in parentheses). "Experience" is the total number of years of educational service in Pennsylvania. In Panel A, "charter" refers to the mean difference in teacher value-added (VAM) for charter school teachers relative to TPS teachers. In Panel B, "CMO" refers to the mean difference in teacher value-added for charter school teachers in a CMO relative to TPS teachers. "Standalone" refers to the mean difference in teacher value-added for charter school teachers in standalone charter schools relative to TPS teachers. "District" is the geographic location of the TPS district (that is, the funding district) in which charter schools are located. The sample includes all full-time teachers teaching in K–12 Pennsylvania public schools in any school year during the 2008–09 through the 2016–17 school years. The coefficients are statistically significant at *10 percent, **5 percent, and ***1 percent levels.

Table C5. Difference in math effectiveness of charter and TPS teachers, by years of experience

	Years of experience									
	1	2	3	4	5	6	7	8	9	10
Panel A. All charters										
Charter	-.012*** (.0041)	.002 (.0043)	-.005 (.0051)	.001 (.0058)	.010 (.0061)	-.005 (.0061)	-.015** (.0061)	-.002 (.0079)	-.005 (.0082)	.002 (.0080)
R^2	.0197	.0162	.0102	.0218	.0159	.0152	.0106	.0079	.0067	.0094
Panel B. Charter type										
Standalone	-.021*** (.0046)	-.004 (.0048)	-.013** (.0056)	-.011* (.0065)	.005 (.0065)	-.012* (.0067)	-.017** (.0065)	-.004 (.0083)	-.005 (.0084)	.004 (.00873)
CMO	.007 (.0074)	.016* (.0086)	.014 (.0100)	.026** (.0107)	.021 (.0133)	.014 (.0124)	-.009 (.0161)	.008 (.0225)	-.000 (.0273)	-.013 (.0239)
R^2	.0240	.0179	.0129	.0261	.0071	.0166	.0107	.0080	.0067	.0096
P-value from F-test: *CMO= Standalone*	.0009	.0435	.0151	.0024	.2922	.0568	.6400	.6043	.8586	.4988
Teacher* years	3,586	3,488	3,331	3,381	3,519	3,905	4,100	4,280	4,180	4,151
Teachers	3,139	3,234	3,034	3,100	3,265	3,586	3,789	3,965	3,873	3,801
Schools	1,361	1,459	1,438	1,462	1,487	1,580	1,666	1,693	1,672	1,647

Notes. Each column (within a panel) is a separate regression. All regressions include year fixed effects. In Panel A, "charter" refers to the mean difference in teacher value-added (VAM) for charter school teachers relative to TPS teachers (coefficients reported with robust standard errors in parentheses). In Panel B, "CMO" refers to the mean difference in teacher value-added for charter school teachers in a CMO relative to TPS teachers (coefficients reported with robust standard errors in parentheses). "Standalone" refers to the mean difference in teacher value-added for charter school teachers in standalone charter schools relative to TPS teachers (coefficients reported with robust standard errors in parentheses). "Years of experience" is the total number of years of educational service in Pennsylvania (for example, one year of experience indicates that teachers are in their first year of teaching in Pennsylvania). The sample includes all full-time teachers teaching in K–12 Pennsylvania public schools in any school year during the 2008–09 through the 2016–17 school years. The coefficients are statistically significant at *10 percent, **5 percent, and ***1 percent levels.

Table C6. Difference in ELA effectiveness of charter and TPS teachers, by years of experience

	Years of experience									
	1	2	3	4	5	6	7	8	9	10
Panel A. All charters										
Charter	.000 (.0025)	.005* (.0029)	.003 (.0030)	.002 (.0034)	-.002 (.0040)	.007 (.0042)	.004 (.0045)	.004 (.0045)	.003 (.0051)	.006 (.0052)
R^2	.0125	.0078	.0035	.0055	.0065	.0069	.0128	.0021	.0031	.0058
Panel B. Charter type										
Standalone	-.003 (.0029)	.001 (.0033)	.001 (.0036)	-.005 (.0037)	-.007 (.0046)	.003 (.0049)	-.001 (.0049)	.004 (.0052)	.002 (.0059)	.009 (.0056)
CMO	.009* (.0048)	.017*** (.0056)	.011** (.0049)	.017** (.0069)	.007 (.0073)	.015** (.0077)	.022** (.0098)	.004 (.0089)	.005 (.0093)	-.009 (.0129)
R^2	.0138	.0097	.0043	.0082	.0074	.0074	.0142	.0021	.0031	.0062
P-value from F-test: *CMO= Standalone*	.0320	.0148	.0748	.0057	.0982	.1891	.0329	.9571	.8062	.1875
Teacher* years	4,144	4,034	3,858	3,939	4,224	4,611	4,751	4,821	4,769	4,684
Teachers	3,623	3,710	3,566	3,608	3,868	4,192	4,394	4,462	4,404	4,313
Schools	1,464	1,540	1,509	1,509	1,556	1,656	1,703	1,736	1,732	1,687

Notes. Each column (within a panel) is a separate regression. All regressions include year fixed effects. In Panel A, "charter" refers to the mean difference in teacher value-added for charter school teachers relative to TPS teachers (coefficients reported with robust standard errors in parentheses). In Panel B, "CMO" refers to the mean difference in teacher value-added for charter school teachers in a CMO relative to TPS teachers (coefficients reported with robust standard errors in parentheses). "Standalone" refers to the mean difference in teacher value-added for charter school teachers in standalone charter schools relative to TPS teachers (coefficients reported with robust standard errors in parentheses). "Years of experience" is the total number of years of educational service in Pennsylvania (for example, one year of experience indicates that teachers are in their first year of teaching in Pennsylvania). The sample includes all full-time teachers teaching in K–12 Pennsylvania public schools in any school year during the 2008–09 through the 2016–17 school years. The coefficients are statistically significant at *10 percent, **5 percent, and ***1 percent levels

Table C7. Nonparametric estimates of the returns to teaching experience, by school sector and alternative experience censoring

Years of experience:	All	TPS	Charter	All	TPS	Charter	All	TPS	Charter
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A. Math									
1	.037*** (.005)	.031*** (.005)	.058*** (.013)	.038*** (.005)	.032*** (.005)	.057*** (.013)	.038*** (.005)	.032*** (.005)	.057*** (.013)
2	.045*** (.006)	.040*** (.006)	.066*** (.017)	.046*** (.006)	.042*** (.006)	.064*** (.017)	.046*** (.006)	.042*** (.006)	.064*** (.017)
3	.053*** (.006)	.048*** (.006)	.083*** (.021)	.055*** (.006)	.050*** (.006)	.080*** (.021)	.055*** (.006)	.050*** (.006)	.080*** (.021)
4	.049*** (.006)	.043*** (.007)	.081*** (.023)	.051*** (.006)	.046*** (.007)	.077*** (.023)	.051*** (.007)	.046*** (.007)	.077*** (.023)
5	.052*** (.007)	.049*** (.007)	.060** (.027)	.055*** (.007)	.052*** (.007)	.055** (.027)	.055*** (.007)	.053*** (.007)	.055** (.027)
6	.059*** (.007)	.056*** (.007)	.031 (.029)	.062*** (.007)	.060*** (.007)	.026 (.029)	.062*** (.007)	.061*** (.008)	.026 (.029)
7	.058*** (.007)	.054*** (.007)	.050 (.032)	.062*** (.007)	.059*** (.008)	.046 (.032)	.062*** (.008)	.059*** (.008)	.046 (.032)
8	.059*** (.007)	.056*** (.008)	.012 (.035)	.064*** (.008)	.062*** (.008)	.008 (.035)	.064*** (.008)	.063*** (.009)	.007 (.035)
9	.063*** (.008)	.059*** (.008)	.078** (.038)	.068*** (.008)	.065*** (.008)	.073* (.038)	.068*** (.009)	.066*** (.009)	.071* (.038)
10	.066*** (.008)	.063*** (.008)	.036 (.040)	.072*** (.009)	.070*** (.009)	.028 (.040)	.072*** (.009)	.071*** (.010)	.025 (.040)
11				.065*** (.009)	.063*** (.009)	.005 (.044)	.065*** (.010)	.065*** (.010)	.002 (.044)
12				.069*** (.010)	.070*** (.010)	-.083* (.047)	.069*** (.010)	.071*** (.011)	-.088* (.048)
13				.067*** (.010)	.067*** (.010)	-.087 (.056)	.067*** (.011)	.069*** (.011)	-.094* (.056)
14				.070*** (.010)	.070*** (.011)	-.071 (.058)	.070*** (.012)	.072*** (.012)	-.083 (.058)
15				.068*** (.011)	.069*** (.011)	-.115** (.057)	.068*** (.012)	.071*** (.012)	-.137** (.059)
16							.077*** (.013)	.079*** (.013)	-.098 (.062)
17							.073*** (.013)	.076*** (.014)	-.044 (.063)
18							.074*** (.014)	.078*** (.014)	-.027 (.062)

cont. on next page...

Years of experience:	All	TPS	Charter	All	TPS	Charter	All	TPS	Charter
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
19							.077*** (.015)	.080*** (.015)	-.045 (.069)
20							.075*** (.015)	.080*** (.016)	-.018 (.088)
P-value from F-test that coefficients equal									
1–10	0.014	0.004	0.001	0.005	0.001	0.001	0.012	0.002	0.010
11–15				0.765	0.506	0.003	0.772	0.491	0.001
16–20							0.475	0.469	0.084
11–20							0.692	0.498	0.007
Student* years	3,796,729								
Students	1,538,188								
Teachers	27,718								
Schools	2,488								
Panel B. ELA	**All**	**TPS**	**Charter**	**All**	**TPS**	**Charter**	**All**	**TPS**	**Charter**
1	.019*** (.004)	.018*** (.004)	.022* (.012)	.019*** (.004)	.018*** (.004)	.022* (.012)	.019*** (.004)	.018*** (.004)	.021* (.012)
2	.028*** (.005)	.025*** (.005)	.030** (.015)	.027*** (.005)	.025*** (.005)	.029** (.015)	.028*** (.005)	.026*** (.005)	.027* (.015)
3	.025*** (.005)	.022*** (.005)	.024 (.016)	.025*** (.005)	.022*** (.005)	.022 (.016)	.025*** (.005)	.023*** (.005)	.020 (.016)
4	.033*** (.005)	.032*** (.005)	.014 (.019)	.033*** (.005)	.032*** (.005)	.011 (.019)	.034*** (.005)	.033*** (.006)	.008 (.019)
5	.035*** (.005)	.032*** (.005)	.028 (.021)	.035*** (.005)	.032*** (.006)	.024 (.020)	.035*** (.006)	.033*** (.006)	.020 (.021)
6	.041*** (.006)	.039*** (.006)	.019 (.024)	.041*** (.006)	.039*** (.006)	.015 (.024)	.041*** (.006)	.040*** (.006)	.010 (.024)
7	.041*** (.006)	.039*** (.006)	.018 (.026)	.041*** (.006)	.039*** (.006)	.013 (.026)	.042*** (.006)	.041*** (.007)	.008 (.026)
8	.045*** (.006)	.043*** (.006)	-.009 (.028)	.044*** (.006)	.043*** (.007)	-.015 (.028)	.045*** (.007)	.045*** (.007)	-.021 (.028)
9	.045*** (.006)	.043*** (.006)	-.022 (.030)	.044*** (.007)	.043*** (.007)	-.029 (.030)	.045*** (.007)	.045*** (.007)	-.035 (.030)
10	.045*** (.007)	.044*** (.007)	-.045 (.033)	.044*** (.007)	.044*** (.007)	-.052 (.032)	.045*** (.008)	.046*** (.008)	-.059* (.033)
11				.051*** (.007)	.049*** (.008)	.018 (.038)	.051*** (.008)	.051*** (.008)	.011 (.038)
12				.052*** (.008)	.051*** (.008)	-.021 (.040)	.053*** (.009)	.053*** (.009)	-.028 (.040)

cont. on next page...

Years of experience:	All	TPS	Charter	All	TPS	Charter	All	TPS	Charter
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
13				.057*** (.008)	.056*** (.008)	-.001 (.041)	.058*** (.009)	.059*** (.009)	-.009 (.041)
14				.056*** (.009)	.056*** (.009)	-.052 (.045)	.057*** (.009)	.058*** (.010)	-.060 (.045)
15				.056*** (.009)	.056*** (.009)	-.046 (.052)	.058*** (.010)	.059*** (.010)	-.055 (.052)
16							.049*** (.010)	.050*** (.011)	-.003 (.049)
17							.054*** (.011)	.055*** (.011)	-.026 (.058)
18							.057*** (.012)	.059*** (.012)	-.053 (.063)
19							.055*** (.012)	.058*** (.012)	-.089 (.069)
20							.057*** (.013)	.060*** (.013)	-.043 (.075)
P-value from F-test that coefficients equal									
1–10	0.000	0.000	0.215	0.001	0.001	0.155	0.002	0.001	0.112
11–15				0.321	0.193	0.250	0.312	0.159	0.243
16–20							0.181	0.101	0.528
11–20							0.176	0.077	0.415
Student* years	5,162,399								
Students	1,558,368								
Teachers	32,326								
Schools	2,488								
Grade* year FE	X	X	X	X	X	X	X	X	X
Teacher* school FE	X	X	X	X	X	X	X	X	X

Notes. Each column is a separate regression. Coefficients are reported with robust standard errors (clustered at the school*grade*year level). All regressions include controls for up to a cubic term of lagged achievement, both in the same subject (math or ELA) and off-subject, student-level controls (age; race; gender; FRL status; SPED status; ELL status; gifted status; class-level controls, which are student-level controls aggregated to the classroom level, including lagged student achievement aggregated to the classroom level; and school-level controls, which are student-level controls aggregated to the school level, including lagged student achievement aggregated to the school level). "Experience" is the number of years a teacher has spent in Pennsylvania public education, which we censor at ten, fifteen, or twenty years. The coefficients are statistically significant at *10 percent, **5 percent, and ***1 percent levels.

Table C8. Nonparametric estimates of the returns to teaching experience, by school sector and charter school type

Years of experience:	Math				
	All	TPS	Charter	Standalone	CMO
	(1)	(2)	(3)	(4)	(5)
1	.037*** (.005)	.031*** (.005)	.058*** (.013)	.068*** (.014)	.063** (.028)
2	.045*** (.006)	.040*** (.006)	.066*** (.017)	.061*** (.018)	.147*** (.037)
3	.053*** (.006)	.048*** (.006)	.083*** (.021)	.103*** (.023)	.123*** (.040)
4	.049*** (.006)	.043*** (.007)	.081*** (.023)	.105*** (.027)	.148*** (.043)
5	.052*** (.007)	.049*** (.007)	.060** (.027)	.081** (.032)	.149*** (.049)
6	.059*** (.007)	.056*** (.007)	.031 (.029)	.065* (.034)	.116** (.057)
7	.058*** (.007)	.054*** (.007)	.050 (.032)	.093** (.037)	.177*** (.064)
8	.059*** (.007)	.056*** (.008)	.012 (.035)	.065 (.040)	.059 (.070)
9	.063*** (.008)	.059*** (.008)	.078** (.038)	.134*** (.043)	.117* (.064)
10	.066*** (.008)	.063*** (.008)	.036 (.040)	.101** (.043)	.081 (.066)
P-values from F-test					
	0.014	0.004	0.001	0.0196	0.048
Student*years	3,796,729				
Students	1,538,188				
Teachers	27,718				
Schools	2,488				

cont. on next page...

Years of experience:	ELA				
	All	TPS	Charter	Standalone	CMO
	(6)	(7)	(8)	(9)	(10)
1	.019*** (.004)	.018*** (.004)	.022* (.012)	.020 (.014)	.061** (.025)
2	.028*** (.005)	.025*** (.005)	.030** (.015)	.016 (.017)	.109*** (.026)
3	.025*** (.005)	.022*** (.005)	.024 (.016)	.000 (.019)	.112*** (.031)
4	.033*** (.005)	.032*** (.005)	.014 (.019)	-.014 (.021)	.113*** (.034)
5	.035*** (.005)	.032*** (.005)	.028 (.021)	-.013 (.024)	.173*** (.037)
6	.041*** (.006)	.039*** (.006)	.019 (.024)	-.020 (.028)	.159*** (.045)
7	.041*** (.006)	.039*** (.006)	.018 (.026)	-.023 (.029)	.150*** (.048)
8	.045*** (.006)	.043*** (.006)	-.009 (.028)	-.054* (.031)	.160*** (.055)
9	.045*** (.006)	.043*** (.006)	-.022 (.030)	-.058* (.033)	.084 (.060)
10	.045*** (.007)	.044*** (.007)	-.045 (.033)	-.080** (.036)	.054 (.066)
P-values from F-test					
	0.000	0.000	0.215	0.244	0.000
Student*years	5,162,399				
Students	1,558,368				
Teachers	32,326				
Schools	2,488				

Notes. Each column (within a panel) is a separate regression. The coefficients are reported with robust standard errors (clustered at the school*grade*year level). All regressions include up to a cubic term of lagged achievement, both in the same subject (math or ELA) and off-subject, student-level controls (age; race; gender; FRL status; SPED status; ELL status; gifted status; class-level controls, which are student-level controls aggregated to the classroom level, including lagged student achievement aggregated to the classroom level; school-level controls, which are student-level controls aggregated to the school level, including lagged student achievement aggregated to the school level; and grade*year and teacher*school fixed effects). "Experience" is the number of years a teacher has spent in Pennsylvania public education and has been censored at ten years. The coefficients are statistically significant at *10 percent, **5 percent, and ***1 percent levels.

Table C9. Year-specific returns to experience across and within sectors

Years of experience:	Math			
	TPS and charter	TPS and standalone	TPS and CMO	Standalone and CMO
	(1)	(2)	(3)	(4)
1	.031*** (.005)	.031*** (.005)	.031*** (.005)	.068*** (.014)
2	.040*** (.006)	.040*** (.006)	.040*** (.006)	.061*** (.018)
3	.048*** (.006)	.048*** (.006)	.048*** (.006)	.103*** (.023)
4	.043*** (.007)	.043*** (.007)	.043*** (.007)	.105*** (.027)
5	.049*** (.007)	.049*** (.007)	.049*** (.007)	.081** (.032)
6	.056*** (.007)	.056*** (.007)	.056*** (.007)	.065* (.034)
7	.054*** (.007)	.054*** (.007)	.054*** (.007)	.093** (.037)
8	.056*** (.008)	.056*** (.008)	.056*** (.008)	.065 (.040)
9	.059*** (.008)	.059*** (.008)	.059*** (.008)	.134*** (.043)
10	.063*** (.008)	.063*** (.008)	.063*** (.008)	.101** (.043)
1*charter	.027* (.014)			
2*charter	.026 (.018)			
3*charter	.036* (.021)			
4*charter	.037 (.024)			
5*charter	.011 (.028)			
6*charter	-.025 (.030)			
7*charter	-.004 (.033)			
8*charter	-.045 (.036)			
9*charter	.019 (.039)			
10*charter	-.027 (.041)			
1*standalone		.037** (.015)		
2*standalone		.021 (.019)		
3*standalone		.055** (.024)		
4*standalone		.062** (.028)		
5*standalone		.032 (.033)		
6*standalone		.008 (.034)		
7*standalone		.039 (.038)		
8*standalone		.009 (.040)		
9*standalone		.075* (.043)		
10*standalone		.038 (.044)		
1*CMO			.032 (.028)	-.005 (.031)

cont. on next page...

Years of experience:	Math			
	TPS and charter	TPS and standalone	TPS and CMO	Standalone and CMO
	(1)	(2)	(3)	(4)
2*CMO			.107*** (.037)	.086** (.041)
3*CMO			.075* (.041)	.020 (.047)
4*CMO			.105** (.044)	.043 (.051)
5*CMO			.100** (.049)	.068 (.059)
6*CMO			.060 (.057)	.052 (.066)
7*CMO			.123* (.064)	.084 (.074)
8*CMO			.002 (.071)	-.006 (.081)
9*CMO			.058 (.065)	-.017 (.077)
10*CMO			.018 (.067)	-.020 (.079)
Student*years	3,796,729			
Students	1,538,188			
Teachers	27,718			

Years of experience:	ELA			
	TPS and charter	TPS and Standalone	TPS and CMO	Standalone and CMO
	(5)	(6)	(7)	(8)
1	.018*** (.004)	.018*** (.004)	.018*** (.004)	.020 (.014)
2	.025*** (.005)	.025*** (.005)	.025*** (.005)	.016 (.017)
3	.022*** (.005)	.022*** (.005)	.022*** (.005)	.000 (.019)
4	.032*** (.005)	.032*** (.005)	.032*** (.005)	-.014 (.021)
5	.032*** (.006)	.032*** (.006)	.032*** (.006)	-.013 (.024)
6	.039*** (.006)	.039*** (.006)	.039*** (.006)	-.020 (.028)
7	.039*** (.006)	.039*** (.006)	.039*** (.006)	-.023 (.029)
8	.043*** (.006)	.043*** (.006)	.043*** (.006)	-.054* (.031)
9	.043*** (.006)	.043*** (.006)	.043*** (.006)	-.058* (.033)
10	.044*** (.007)	.044*** (.007)	.044*** (.007)	-.080** (.036)
1*charter	.005 (.013)			
2*charter	.005 (.015)			
3*charter	.002 (.017)			
4*charter	-.017 (.019)			
5*charter	-.004 (.021)			
6*charter	-.019 (.025)			

cont. on next page...

Years of experience:	ELA			
	TPS and charter	TPS and Standalone	TPS and CMO	Standalone and CMO
	(5)	(6)	(7)	(8)
7*charter	-.021 (.026)			
8*charter	-.052* (.028)			
9*charter	-.065** (.030)			
10*charter	-.088*** (.033)			
1*standalone		.002 (.015)		
2*standalone		-.009 (.018)		
3*standalone		-.022 (.020)		
4*standalone		-.046** (.022)		
5*standalone		-.045* (.024)		
6*standalone		-.059** (.029)		
7*standalone		-.062** (.030)		
8*standalone		-.097*** (.032)		
9*standalone		-.100*** (.034)		
10*standalone		-.124*** (.037)		
1*CMO			.044* (.025)	.041 (.029)
2*CMO			.084*** (.027)	.093*** (.031)
3*CMO			.090*** (.031)	.112*** (.036)
4*CMO			.081** (.035)	.126*** (.040)
5*CMO			.141*** (.038)	.186*** (.044)
6*CMO			.120*** (.045)	.179*** (.053)
7*CMO			.111** (.048)	.173*** (.056)
8*CMO			.117** (.055)	.214*** (.063)
9*CMO			.042 (.060)	.142** (.069)
10*CMO			.010 (.066)	.134* (.075)
Student*years	5,162,399			
Students	1,558,368			
Teachers	32,326			

Notes. Each column is a separate regression. The coefficients are reported with robust standard errors (clustered at the school*grade*year level). All regressions include up to a cubic term of lagged achievement, both in the same subject (math or ELA) and off-subject, student-level controls (age; race; gender; FRL status; SPED status; ELL status; gifted status; class-level controls, which are student-level controls aggregated to the classroom level, including lagged student achievement aggregated to the classroom level; school-level controls, which are student-level controls aggregated to the school level, including lagged student achievement aggregated to the school level; and grade*year and teacher*school fixed effects). We interact each covariate and fixed effect with an indicator for either charter, standalone, or CMO, depending on the specification. "Experience" is the number of years a teacher has spent in Pennsylvania public education and has been censored at ten years. The coefficients are statistically significant at *10 percent, **5 percent, and ***1 percent levels.

Table C10. Teacher mobility rates, by mobility type and sector

	All	TPS	Charter		
			All	CMO	Standalone
Any mobility	.1468	.1369	.3481***	.4141	.3237***
Interdistrict mobility	.0096	.0081	.0406***	.0338	.0431
Intradistrict mobility	.0472	.0460	.0730***	.0936	.0654***
Intraschool mobility	.0329	.0305	.0804***	.0982	.0738***
Role mobility	.0097	.0087	.0310***	.0425	.0267***
Exit PA	.0474	.0436	.1231***	.1460	.1147***

Notes. Cells report proportions. See *Mobility Pathways* on page 12 for definitions. Sample includes all full-time teachers teaching in K–12 Pennsylvania public schools during the 2008–09 through the 2015–16 school years (TPS includes 113,471 teacher*year observations; charter includes 5,588 teacher*year observations; CMO includes 1,507 teacher*year observations; and standalone includes 4,081 teacher*year observations). The differences between teachers in traditional and charter schools are statistically significant at *10 percent, **5 percent, and ***1 percent levels (and are indicated in the "all charter" column); the differences between teachers in CMO and standalone charter schools are statistically significant at *10 percent, **5 percent, and ***1 percent levels (and are indicated in the "standalone" column).

Table C11. Within-sector differences in teacher effectiveness, by teacher mobility

	Math VAM			
	(1)	(2)	(3)	(4)
Panel A. TPS				
Interdistrict mobility	-.004 (.0035)	-.005 (.0035)	-.006* (.0035)	-.009*** (.0034)
Intradistrict mobility	-.007*** (.0017)	-.007*** (.0017)	-.010*** (.0017)	-.008*** (.0018)
Intraschool mobility	-.009*** (.0019)	-.010*** (.0020)	-.010*** (.0020)	-.011*** (.0020)
Role mobility	-.004 (.0041)	-.004 (.0041)	-.003 (.0040)	-.004 (.0041)
Exit PA	-.014*** (.0018)	-.014*** (.0017)	-.016*** (.0017)	-.016*** (.0017)
R^2	.0015	.0096	.0591	.1632
P-value from F-test: Coefficients equal	.0051	.0054	.0079	.0079
Teacher*years	65,321			
Teachers	23,945			
Schools	2,312			
Panel B. All charters				
Interdistrict mobility	-.014* (.0077)	-.012 (.0078)	-.005 (.0083)	-.007 (.0085)
Intradistrict mobility	-.005 (.0069)	-.004 (.0069)	-.006 (.0071)	-.006 (.0073)
Intraschool mobility	.003 (.0065)	.003 (.0064)	.003 (.0066)	-.001 (.0069)
Role mobility	.027** (.0124)	.025** (.0119)	.028** (.0117)	.026** (.0119)
Exit PA	-.008 (.0054)	-.008 (.0054)	-.008 (.0055)	-.011* (.0056)
R^2	.0035	.0234	.0572	.1265
P-value from F-test: Coefficients equal	.0376	.0628	.0396	.0636
Panel C. CMO				
Interdistrict mobility	-.061*** (.0170)	-.054*** (.0177)	-.037** (.0177)	-.045** (.0197)
Intradistrict mobility	.001 (.0130)	.006 (.0135)	.000 (.0136)	.003 (.0139)
Intraschool mobility	.008 (.0125)	.008 (.0121)	.019 (.0125)	.014 (.0125)
Role mobility	.042 (.0279)	.036 (.0251)	.038 (.0251)	.043 (.0265)
Exit PA	-.026** (.0122)	-.025** (.0119)	-.028** (.0119)	-.027** (.0122)
R^2	.0219	.0897	.1207	.1402
P-value from F-test: Coefficients equal	.0007	.0024	.0027	.0032
Teacher*years	828			
Teachers	500			
Schools	39			

cont. on next page...

	Math VAM			
	(1)	(2)	(3)	(4)
Panel D. Standalone				
Inter-District Mobility	.001 (.0084)	.001 (.0085)	.002 (.0093)	.002 (.0093)
Intra-District Mobility	-.012 (.0081)	-.011 (.0081)	-.011 (.0084)	-.012 (.0085)
Intra-School Mobility	-.002 (.0076)	-.002 (.0075)	-.006 (.0077)	-.009 (.0081)
Role Mobility	.015 (.0109)	.012 (.0107)	.017 (.0104)	.010 (.0107)
Exit PA	-.003 (.0059)	-.004 (.0058)	-.003 (.0060)	-.006 (.0061)
R^2	.0016	.0158	.0580	.0580
P-value from F-Test: Coefficients equal	.3762	.4670	.2433	.1455
Teacher*Years	2,524			
Teachers	1,333			
Schools	111			
Year FE		X	X	
District FE			X	
District*Year FE				X

	ELA VAM			
	(5)	(6)	(7)	(8)
Panel A. TPS				
Interdistrict mobility	-.011*** (.0024)	-.011*** (.0024)	-.011*** (.0023)	-.010*** (.0022)
Intradistrict mobility	-.003** (.0011)	-.003** (.0011)	-.004*** (.0011)	-.004*** (.0011)
Intraschool mobility	-.006*** (.0012)	-.006*** (.0012)	-.007*** (.0012)	-.006*** (.0012)
Role mobility	.001 (.0022)	.001 (.0022)	.001 (.0022)	.001 (.0021)
Exit PA	-.007*** (.0010)	-.007*** (.0010)	-.007*** (.0010)	-.007*** (.0010)
R^2	.0011	.0048	.0636	.1894
P-value from F-test: Coefficients equal	.0002	.0002	.0002	.0009
Teacher*years	77,828			
Teachers	28,191			
Schools	2,311			
Panel B. All charters				
Interdistrict mobility	-.005 (.0048)	-.005 (.0048)	-.002 (.0051)	-.002 (.0052)
Intradistrict mobility	-.004 (.0046)	-.004 (.0045)	-.005 (.0046)	-.007 (.0047)
Intraschool mobility	.000 (.0043)	-.000 (.0043)	-.001 (.0043)	-.005 (.0045)
Role mobility	.000 (.0066)	-.000 (.0065)	.005 (.0064)	.004 (.0065)

cont. on next page...

	ELA VAM			
	(5)	(6)	(7)	(8)
Exit PA	-.010*** (.0036)	-.010*** (.0036)	-.010*** (.0036)	-.010*** (.0036)
R^2	.0025	.0205	.0675	.1437
P-value from F-test: Coefficients equal	.3241	.3401	.1655	.2926
Panel C. CMO				
Interdistrict mobility	-.021* (.0114)	-.021* (.0111)	-.018* (.0105)	-.024** (.0106)
Intradistrict mobility	-.001 (.0067)	-.001 (.0067)	-.004 (.0068)	-.004 (.0069)
Intraschool mobility	-.002 (.0071)	-.004 (.0070)	.003 (.0069)	.000 (.0072)
Role mobility	.009 (.0112)	.008 (.0112)	.014 (.0111)	.010 (.0122)
Exit PA	-.013* (.0067)	-.014** (.0065)	-.015** (.0065)	-.013* (.0067)
R^2	.0077	.0523	.0648	.1138
P-value from F-test: Coefficients equal	.1763	.1718	.0474	.1119
Teacher*years	886			
Teachers	524			
Schools	39			
Panel D. Standalone				
Inter-District Mobility	-.001 (.0053)	-.001 (.0053)	.002 (.0057)	.000 (.0058)
Intra-District Mobility	-.007 (.0059)	-.007 (.0059)	-.006 (.0060)	-.009 (.0061)
Intra-School Mobility	.000 (.0055)	.000 (.0055)	-.004 (.0054)	-.006 (.0056)
Role Mobility	-.007 (.0081)	-.007 (.0079)	-.003 (.0075)	-.003 (.0076)
Exit PA	-.009** (.0042)	-.009** (.0043)	-.009** (.0043)	-.010** (.0042)
R^2	.0026	.0171	.0734	.1657
P-value from F-Test: Coefficients equal	.5555	.5396	.5988	.6627
Teacher*Years	2,644			
Teachers	1,444			
Schools	111			
Year FE		X	X	
District FE			X	
District*Year FE				X

Notes. Each column (within a panel) is a separate regression (the coefficients are reported with robust standard errors in parentheses). See *Mobility Pathways* on page 12 for definitions. The comparison group includes teacher*year observations (within a sector) that are not mobile at the end of the academic year. "District" is the geographic location of the TPS district (that is, the funding district) in which charter schools are located. Sample includes all full-time teachers teaching in K–12 Pennsylvania public schools in any school year during the 2008–09 through the 2015–16 school years. The coefficients are statistically significant at *10 percent, **5 percent, and ***1 percent levels.

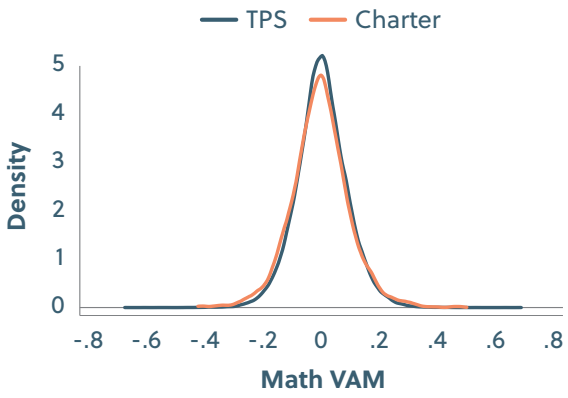
Table C12. Distribution of Non-Teaching Roles in the Year After Charter Teachers Change Professional Roles in PA

	All	Remain in Charter Sector			TPS
		Same School	Same CMO	New School	
Panel A. All Charter Teachers					
Principal	0.02	0.02	0.00	0.05	0.00
Assistant Principal	0.16	0.13	0.38	0.27	0.00
Instructional Supervisor	0.48	0.48	0.15	0.55	0.75
Other Roles	0.34	0.37	0.46	0.14	0.25
Teachers	173	126	13	22	12
Panel B. CMO Charter Teachers					
Principal	0.00	0.00	0.00	0.00	0.00
Assistant Principal	0.22	0.18	0.38	0.25	0.00
Instructional Supervisor	0.36	0.38	0.15	0.50	1.00
Other Roles	0.42	0.44	0.46	0.25	0.00
Teachers	64	45	13	4	2
Panel B. Standalone Charter Teachers					
Principal	0.04	0.04	0.00	0.06	0.00
Assistant Principal	0.13	0.11	0.00	0.28	0.00
Instructional Supervisor	0.55	0.53	0.00	0.56	0.7
Other Roles	0.28	0.32	0.00	0.11	0.3
Teachers	109	81	0	18	10

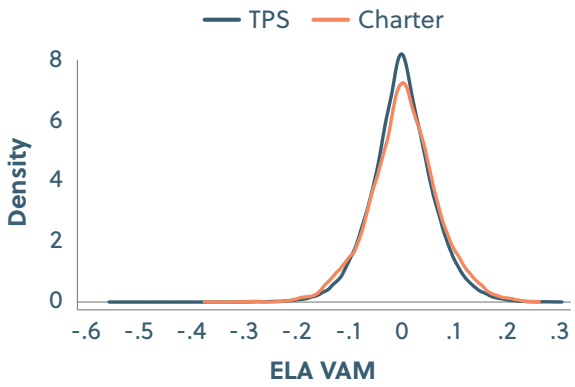
Notes. Each cell represents a proportion. The sample includes all charter school teachers who left teaching but remained in Pennsylvania public education in a nonteaching role in the subsequent school year (that is, role mobility). Panel A includes all charter teachers; Panel B includes only charter teachers who left teaching from a CMO; and Panel C includes only teachers who left teaching from a standalone charter school. "Same school" refers to the proportion of teachers who left their teaching role and became either a principal, assistant principal, instructional supervisor, or took on another nonteaching role at the school where they left teaching. "Same CMO" refers to the proportion of teachers who left their teaching role and became either a principal, assistant principal, instructional supervisor, or took on another nonteaching role within the same CMO but at a different school. "New school" refers to the proportion of teachers who left their teaching role and became either a principal, assistant principal, instructional supervisor, or took on another nonteaching role at a different school. TPS refers to the proportion of charter teachers that left teaching and became either a principal, assistant principal, instructional supervisor, or took on another nonteaching role at a traditional public school.

Figure C1. Distribution of Teacher Effectiveness, by Sector and Subject

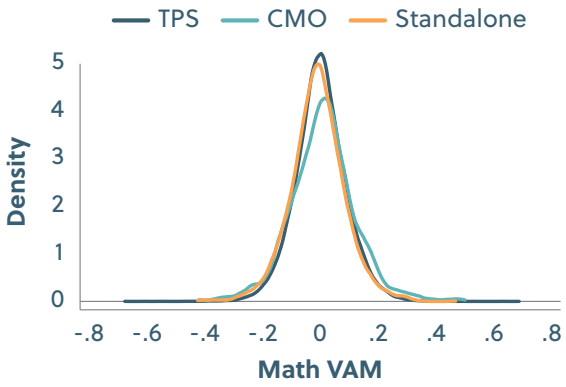
Panel A. Math VAM (All Charters)



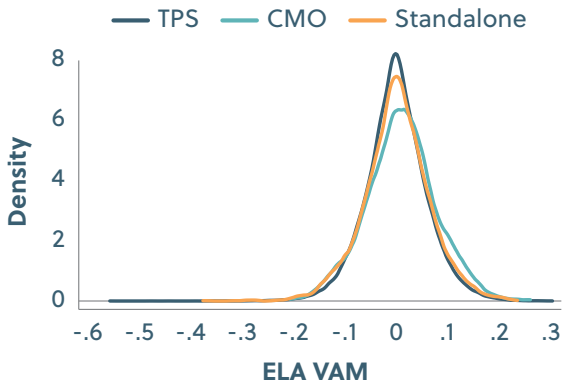
Panel B. ELA VAM (All Charters)



Panel C. Math VAM (Charter Type)



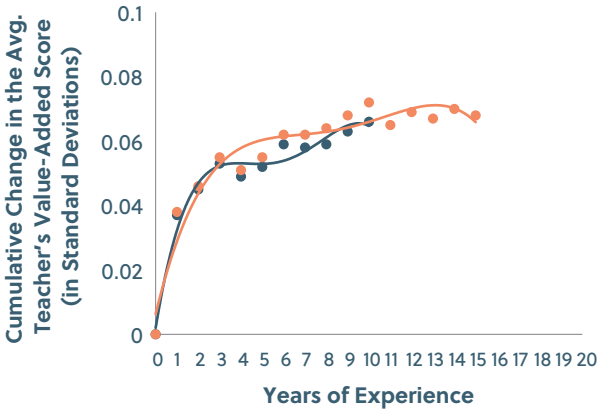
Panel D. ELA VAM (Charter Type)



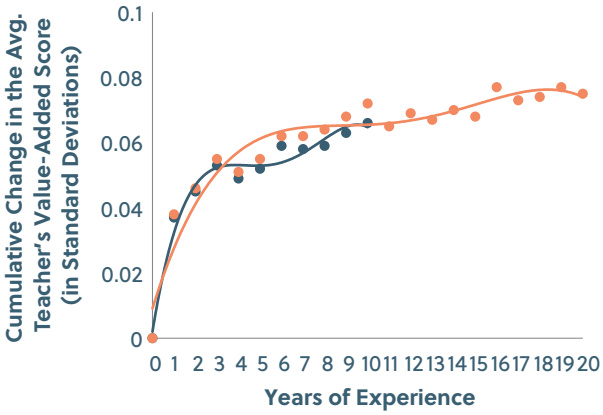
Notes. Teacher value-added (VAM) estimates are from the 2008–09 through 2016–17 school years. In Panel A, mean (standard deviation) Math value-added is .0013 (.088) for TPS teachers and -.0046 (.100) for charter teachers; a two-sample Kolmogorov-Smirnov test for the equality of distribution functions rejects the null hypothesis that math value-added for TPS and charter school teachers is drawn from the same distribution ($p<0.0001$). In Panel B, mean (standard deviation) ELA value-added is -.0001 (.060) for TPS teachers and .0027 (.066) for charter teachers; a two-sample Kolmogorov-Smirnov test for the equality of distribution functions rejects the null hypothesis that ELA value-added for TPS and charter school teachers is drawn from the same distribution ($p<0.0001$). In Panel C, mean (standard deviation) Math value-added is .0085 (.114) for CMO teachers and -.0091 (.095) for standalone charter teachers; a two-sample Kolmogorov-Smirnov test for the equality of distribution functions rejects the null hypothesis that math value-added for CMO and standalone charter school teachers is drawn from the same distribution ($p<0.0001$). In Panel D, mean (standard deviation) ELA value-added is .0094 (.068) for CMO teachers and .0004 (.065) for standalone charter teachers; a two-sample Kolmogorov-Smirnov test for the equality of distribution functions rejects the null hypothesis that ELA value-added for CMO and standalone charter school teachers is drawn from the same distribution ($p<0.0001$). In Panel A, there are 83,372 teacher*year observations and 27,718 unique teachers across 2,488 schools (TPS: 79,246 teacher*year observations, 25,806 unique teachers, 2,337 schools; charter: 4,126 teacher*year observations, 2,093 unique teachers, 151 schools). In Panel B, there are 97,925 teacher*year observations and 32,326 unique teachers across 2,488 schools (TPS: 93,582 teacher*year observations, 30,248 unique teachers, 2,336 schools; charter: 4,343 teacher*year observations, 2,248 unique teachers, 152 schools). In Panel C, CMOs have 1,041 teacher*year observations, 610 unique teachers, and forty-three schools; standalone charters have 3,085 teacher*year observations, 1,542 unique teachers, and 114 schools. In Panel D, CMOs have 1,107 teacher*year observations, 641 unique teachers, and forty-three schools; standalone charters have 3,236 teacher*year observations, 1,676 unique teachers, and 115 schools.

Figure C2. Estimated Returns to Teacher Experience, by Subject and Alternative Experience Censoring

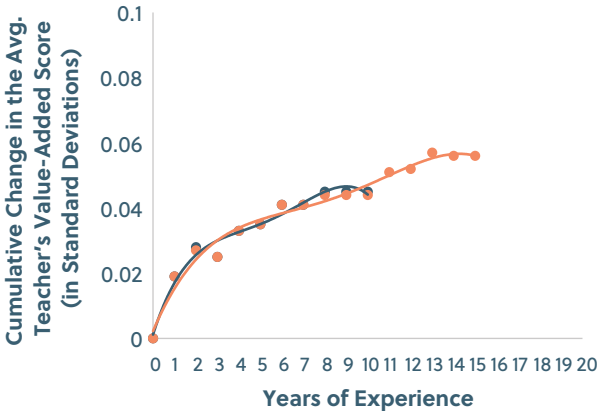
Panel A. Math (Censoring at 10 and 15 Years)



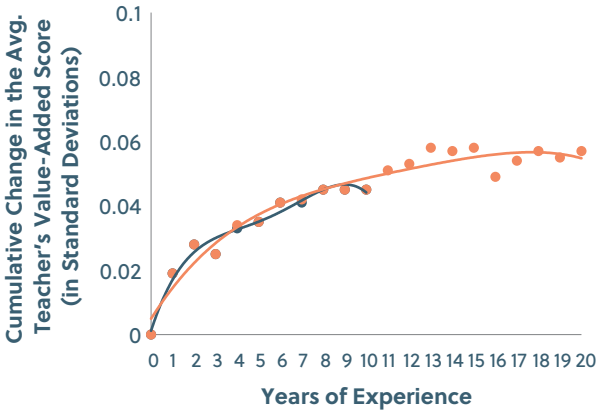
Panel B. Math (Censoring at 10 and 20 Years)



Panel C. ELA (Censoring at 10 and 15 Years)

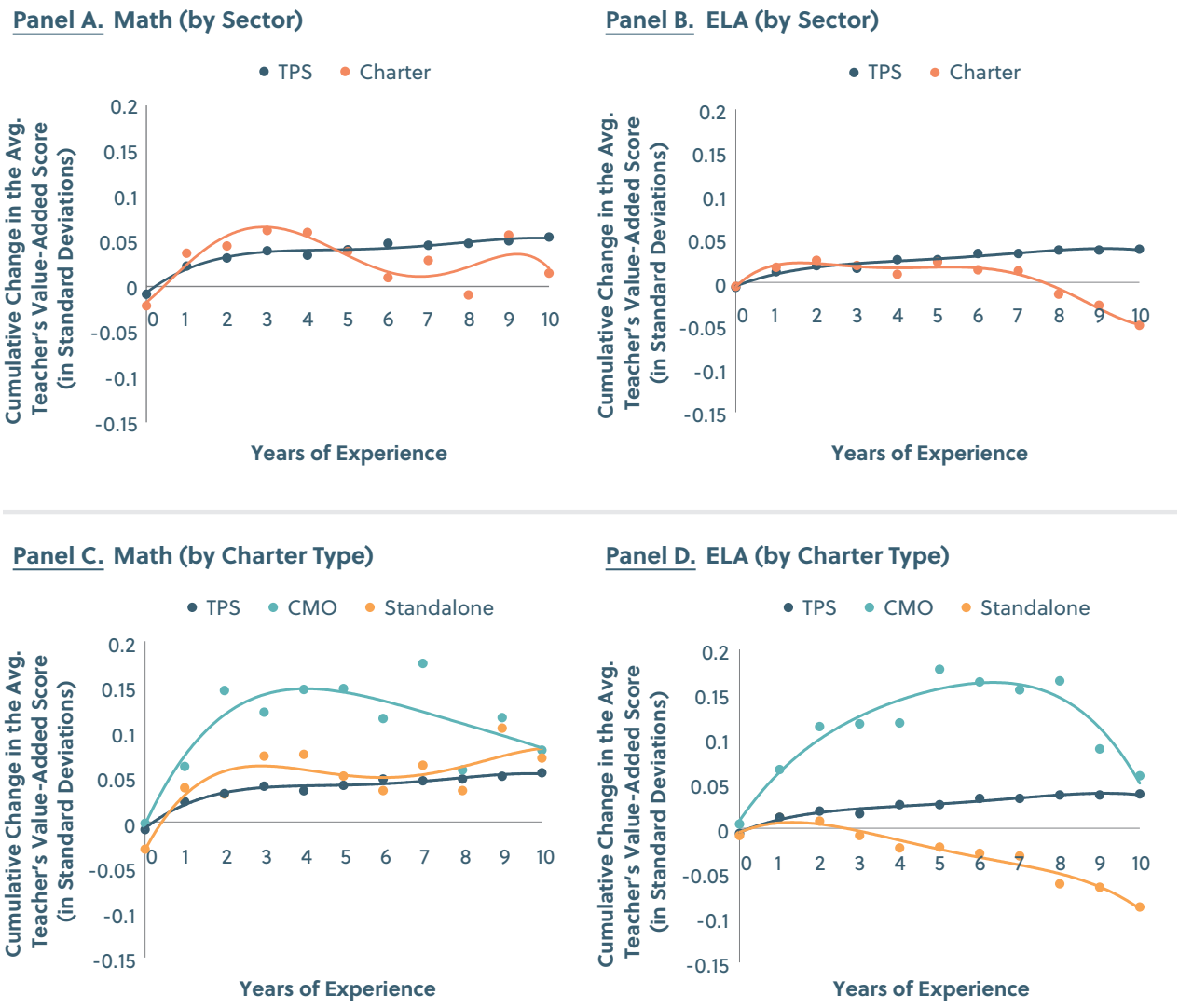


Panel D. ELA (Censoring at 10 and 20 Years)



Notes. Each panel presents nonparametric results for ten years of censoring and either fifteen or twenty years of censoring, with a fitted quartic function overlaid on the nonparametric estimates. Panels A and C present results for math and ELA at ten and fifteen years of censoring, and Panels B and D present results for math and ELA at ten and twenty years of censoring. All regressions include grade*year and teacher*school fixed effects; up to a cubic term of lagged achievement, both in the same subject (math or ELA) and off-subject; student-level controls (age, race, gender, FRL status, SPED status, ELL status, and gifted status); class-level controls, which are student-level controls aggregated to the classroom level, including lagged student achievement aggregated to the classroom level; and school-level controls, which are student-level controls aggregated to the school level, including lagged student achievement aggregated to the school level. See Appendix Table C7 for point estimates upon which these figures are based.

Figure C3. Estimated Returns to Teacher Experience, by Sector and Charter School Type



Notes. Each panel shows estimated within-teacher effectiveness across the experience distribution. The estimated within-teacher effectiveness profile begins at year zero with the average value-added (VAM) for novice teachers by sector. The estimated effectiveness profile relies on the within-teacher estimated returns to experience (see Appendix Table C8). Each panel shows the estimated within-teacher effectiveness profile across the experience distribution with a fitted quartic function overlaid on the nonparametric estimates. All regressions include grade*year and teacher*school fixed effects; up to a cubic term of lagged achievement, both in the same subject (math or ELA) and off-subject; student-level controls (age, race, gender, FRL status, SPED status, ELL status, and gifted status), class-level controls, which are student-level controls aggregated to the classroom level, including lagged student achievement aggregated to the classroom level; and school-level controls, which are student-level controls aggregated to the school level, including lagged student achievement aggregated to the school level. Average math value-added for novice teachers (that is, year zero) by sector and subject are as follows: -0.0085 (TPS); -0.0213 (charter); -0.0302 (standalone); and -0.0015 (CMO). Average ELA value-added for novice teachers (that is, year zero) by sector and subject are as follows: -0.0057 (TPS); -0.0045 (charter); -0.008 (standalone); and 0.0047 (CMO). See Appendix Table C8 for point estimates upon which these figures are based.

Endnotes

1 CMOs are nonprofit organizations that operate multiple charter schools and often provide back-office functions or other forms of support to individual schools. Standalone charter schools operate independently, meaning they are not part of a larger management organization. Virtual charter schools are omitted.

2 Aaronson, Daniel, Lisa Barrow, and William Sander. "Teachers and student achievement in the Chicago Public High Schools. *Journal of Labor Economics* 25, no. 1 (2007): 95–135. doi:10.1086/508733; Chetty, Raj, John N. Friedman, and Jonah E. Rockoff. "Measuring the Impacts of Teachers II: Teacher Value-Added and Student Outcomes in Adulthood." *American Economic Review* 104, no. 9 (2014): 2633–79. doi:10.1257/aer.104.9.2633; Jackson, C. Kirabo, Shanette C. Porter, John Q. Easton, Alyssa Blanchard, and Sebastián Kiguel. "School Effects on Socio-emotional Development, School-Based Arrests, and Educational Attainment." *American Economic Review: Insights* (forthcoming); Kraft, M. A. (2019). "Teacher effects on complex cognitive skills and social-emotional competencies." *Journal of Human Resources*, 54(1), 1-36; Rivkin, Steven G., Eric A. Hanushek, and John F. Kain. "Teachers, Schools, and Academic Achievement." *Econometrica* 73, no. 2 (2005): 417–58; and Rockoff, Jonah E. "The Impact of Individual Teachers on Student Achievement: Evidence from Panel Data." *American Economic Review* 94, no. 2 (2004): 247–52. doi:10.1257/0002828041302244.

3 Henry, Gary T., Kevin C. Bastian, and C. Kevin Fortner. "Stayers and Leavers: Early-Career Teacher Effectiveness and Attrition." *Educational Researcher* 40, no. 6 (2011): 271–80. doi:10.3102/0013189X11419042; Kraft, Matthew A., and John P. Papay. "Can Professional Environments in Schools Promote Teacher Development? Explaining Heterogeneity in Returns to Teaching Experience." *Educational Evaluation and Policy Analysis* 36, no. 4 (2014): 476–500. doi:10.3102/0162373713519496; Ladd, Helen F., and Lucy C. Sorenson. "Returns to Teacher Experience: Student Achievement and Motivation in Middle School." *Education Finance and Policy* 12, no. 2 (2017): 241–79. https://eric.ed.gov/?id=EJ1137958; Papay, John P., and Matthew A. Kraft. "Productivity Returns to Experience in the Teacher Labor Market: Methodological Challenges and New Evidence on Long-Term Career Improvement." *Journal of Public Economics* 130 (2015): 109–19. doi:10.1016/j.jpubeco.2015.02.008; and Rockoff, 2004.

4 For example, evidence from Florida indicates that charter school teachers are approximately twice as likely to exit teaching than their TPS counterparts. Cowen, Joshua M., and Marcus A. Winters. "Do Charters Retain Teachers Differently? Evidence from Elementary Schools in Florida." *Education Finance and Policy* 8, no. 1 (2013): 14–42. doi:10.1162/EDFP_a_00081.

5 Steinberg, Matthew P., and Matthew A. Kraft. "The Sensitivity of Teacher Performance Ratings to the Design of Teacher Evaluation Systems." *Educational Researcher* 46, no. 7 (2017): 378–96. doi:10.3102/0013189X17726752.

6 Chetty, Friedman, & Rockoff, 2014

7 Kraft & Papay, 2014; Ladd & Sorenson, 2017; Papay & Kraft, 2015; and Rockoff, 2004.

8 Jackson, C. Kirabo, and Elias Bruegmann. "Teaching Students and Teaching Each Other: The Importance of Peer Learning for Teachers." *American Economic Journal: Applied Economics* 1, no. 4 (2009): 85–108. doi:10.1257/app.1.4.85.

9 Cannata, Marisa, and Roberto Penaloza. "Who Are Charter School Teachers? Comparing Teacher Characteristics, Job Choices, and Job Preferences." *Education Policy Analysis Archives/Archivos Analíticos de Políticas Educativas* 20, no. 29 (2012): 1–21. doi:10.14507/epaa.v20n29.2012; Ni, Yongmei. "Teacher Working Conditions in Charter Schools and Traditional Public Schools: A Comparative Study." *Teachers College Record* 114, no. 3 (2012): 1–26. https://eric.ed.gov/?id=EJ1000004; and Hussar, B., Zhang, J., Hein, S., Wang, K., Roberts, A., Cui, J., Smith, M., Bullock Mann, F., Barmer, A., and Dilig, R. (2020). *The Condition of Education 2020* (NCES 2020-144). U.S. Department of Education. Washington, DC: National Center for Education Statistics. https://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2020144.

10 Cannata, Marisa. "Charter Schools and the Teacher Job Search." *Journal of School Choice* 5, no. 1 (2011): 111–33. doi:10.1080/15582159.2011.548256.

11 Carruthers, Celeste K. "The Qualifications and Classroom Performance of Teachers Moving to Charter Schools." *Education Finance and Policy* 7, no. 3 (2012): 233–68. doi:10.1162/EDFP_a_00067; Cohodes, Sarah, Elizabeth Setren, and Christopher R. Walters. "Can Successful Schools Replicate? Scaling Up Boston's Charter School Sector." National Bureau of Economic Research working paper no. 25796 , 2019. doi:10.3386/w25796; and Cowen & Winters, 2013.

12 Cowen & Winters, 2013

13 Bruhn, Jesse, Scott Imberman, and Marcus Winters "Regulatory Arbitrage in Teacher Hiring and Retention: Evidence from Massachusetts Charter Schools." EdWorkingPaper 20-264 (2020). doi:10.26300/83ff-gd98.

14 Cowen & Winters, 2013, and Carruthers, 2012.

15 Ozek, Umut, Celeste Carruthers, and Kristian Holden. "Teacher Value-Added in Charter Schools and Traditional Public Schools." CALDER: Center for Analysis of Longitudinal Data in Education Research, working paper 183, 2018. https://eric.ed.gov/?id=ED583625.

16 Cohodes et al., 2019.

17 The starting salary for Pennsylvania teachers, in nominal terms, has been $18,500 for more than 30 years. See Commonwealth of Pennsylvania, 2020: https://www.governor.pa.gov/newsroom/gov-wolf-calls-teacher-to-discuss-pay-in-new-video/

18 Kane, Thomas J., and Douglas O. Staiger. *Gathering Feedback for Teaching: Combining High-Quality Observations with Student Surveys and Achievement Gains*. Seattle, WA: Bill and Melinda Gates Foundation, 2012. http://www.metproject.org/downloads/MET_Gathering_Feedback_Research_Paper.pdf; and Steinberg & Kraft (2017).

19 We convert student-level standard deviations for both math and ELA into days of student learning using empirical benchmarks for annual student learning gains from Bloom, Howard S., Carolyn J. Hill, Alison Rebeck Black, and Mark W. Lipsey. "Performance Trajectories and Performance Gaps as Achievement Effect-Size Benchmarks for Educational Interventions." *Journal of Research on Educational Effectiveness* 1, no. 4 (2008): 289–328. doi:10.1080/19345740802400072.

20 Of the 6,859 charter teacher*year observations in our analytic sample, 4,763 (69.4 percent) are in urban districts. For the sample of charter teachers with math VAM, 67.8 percent (2,796) of the 4,126 charter teacher*year observations are in urban districts; for the sample of charter teachers with ELA VAM, 67.3 percent (2,922) of the 4,343 charter teacher*year observations are in urban districts.

21 Center for Research on Education Outcomes. *Charter School Performance in Pennsylvania 2019* (Stanford, CA: Center for Research on Education Outcomes, 2019). https://credo.stanford.edu/sites/g/files/sbiybj6481/f/2019_pa_state_report_final_06052019.pdf. See also the 2015 report.

22 Kraft & Papay, 2014; Ladd & Sorenson, 2017; and Papay & Kraft, 2015.

23 Appendix Table C9 presents formal significance tests of the differences between the year-specific returns to experience in charter and traditional public schools.

24 Appendix Figure C3 shows average teacher effectiveness by year of experience and charter school type, where we set year zero—a teacher's novice year—equal to the average effectiveness of novice teachers, by sector.

25 The only teacher-mobility event that does not result in a teacher exit from school is intraschool mobility, whereby a teacher teaches a new subject or grade level within the same school in the next academic year.

26 In alternative analyses, we estimated teacher-mobility rates net of school poverty (that is, the share of a school's students receiving FRL); the difference in mobility rates across charter and traditional public schools remains approximately the same.

27 Lake, Robin, Melissa Bowen, Allison Demeritt, Moira McCullough, Joshua Haimson, and Brian Gill. *Learning from Charter School Management Organizations: Strategies for Student Behavior and Teacher Coaching.* Cambridge, MA: Mathematica Policy Research, Inc., 2012. https://eric.ed.gov/?id=ED530801.

28 Steinberg, Matthew P., and Lauren Sartain. "Does Teacher Evaluation Improve School Performance? Experimental Evidence from Chicago's Excellence in Teaching Project." *Education Finance and Policy* 10, no. 4 (2015): 535–72. https://eric.ed.gov/?id=EJ1077268; and Steinberg, Matthew P., and Lauren Sartain. "Does Better Observation Make Better Teachers?" *Education Next* 15, no. 1 (2015): 70–76.

29 For each student who is missing a prior-year test score for the off-subject exam (for example, if math achievement is the outcome for student *i* in year *t*, then the ELA test score in year *t-1* is the off-subject prior-year test score), we set the value of the off-subject exam equal to zero and include an indicator variable for missingness that we set equal to one.

30 We include an indicator variable for those teacher-year observations for which we censor experience.