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Virtual Charter Students Have Worse Labor Market Outcomes as Young Adults

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Abstract

Virtual charter schools are increasingly popular, yet there is no research on the long-term outcomes of virtual charter students. We link statewide education records from Oregon with earnings information from IRS records housed at the U.S. Census Bureau to provide evidence on how virtual charter students fare as young adults. Virtual charter students have substantially worse high school graduation rates, college enrollment rates, bachelor's degree attainment, employment rates, and earnings than students in traditional public schools. Although there is growing demand for virtual charter schools, our results suggest that students who enroll in virtual charters may face negative long-term consequences.

Main Text

In the 2021-22 academic year, more than 500,000 public K-12 students attended fully virtual schools. Most of these students attended virtual charter schools (NCES, 2022). While the virtual charter sector had been growing prior to the COVID-19 pandemic's onset, the pandemic dramatically accelerated the sector's growth (GAO 2022; Gratz et al., 2022). As families, educators, and leaders around the world grapple with the consequences of the pandemic and virtual schooling's consequences for youth development, it is increasingly important to understand the implementation and effectiveness of virtual charter schools and virtual learning more broadly (Goldhaber et al, 2022). In this paper, we provide the first evidence on the young adult outcomes of students who attended virtual charter schools.

Existing research suggests that students enrolled in virtual charter schools – publicly funded charter schools where instruction is entirely virtual – suffer worse academic outcomes than their peers in traditional public face-to-face settings. Virtual charter students in elementary and middle school experience decreases in their academic achievement ranging from -.1 to -.4 SD in math, English Language Arts, social studies, and science (CREDO, 2015; Ahn and McEachin, 2017; Bueno, 2020; Fitzpatrick et al, 2020). Similar outcomes hold for high school students, the vast majority of virtual charter school enrollees (e.g. Ahn and McEachin, 2017; Bueno, 2020). High school students attending virtual high schools were less likely to pass their high school graduation requirements regardless of their entering achievement level (Ahn and McEachin, 2017) and were 10 percentage points less likely to ever graduate from high school (Bueno 2020). We contribute to this literature by tracking postsecondary educational attainment and early labor market outcomes for students who attended virtual charter high schools.

We link statewide education data from Oregon's Department of Education with earnings data from the Internal Revenue Service (IRS) to analyze how long-term educational attainment and labor market outcomes are associated with attending virtual charter school in 9th grade. Our primary analytic sample includes students who entered high school between the 2005-06 and 2010-11 school years. We examine high school degree attainment and college enrollment as well as formal employment and earnings 6 years after high school. For a subset of these students (the 2005-06 to 2008-09 cohorts), we additionally examine associate's and bachelor's degree attainment within 3 and 5 years after high school, respectively; as well as formal employment and earnings 8 years after high school.

Results

Approximately 800 8th grade students who attended traditional public schools enrolled in virtual charter schools in 9th grade. Compared to students attending traditional public schools, these virtual charter students were more likely to be white, female, and economically disadvantaged; less likely to report English as their native language or be categorized as special education or gifted; and had lower average test scores and missed more school as 8th graders. To account for these differences, we estimate doubly robust models using propensity score weights from TWANG (Toolkit for Weighting and Analysis of Nonequivalent Groups; Ridgeway et al., 2017), a machine learning algorithm that utilizes gradient boosted models to iteratively generate propensity score weights based on what school students attended in 8th grade, student demographics, academic information, and family income. As visible in Table 1, our weights provide good balance across these covariates, and once weights are applied our traditional public

school students have similar pre-treatment means as the students who attended virtual charter schools.

[Insert Table 1 about here.]

Our models compare the outcomes of students who attended virtual charter schools to observationally similar students in traditional schools, thus providing an indication of how virtual school students might have fared if they had stayed in traditional schools. Importantly, however, although we compare students to others who also attended the same 8th grade school and are observationally similar in terms of family income and prior achievement, our approach cannot account for the possibility that there are unobserved characteristics of the students and their families that make them less likely to attend in-person schools (and also less likely to attend college or participate in the labor market). As such, although analyses suggest that unobserved characteristics would have to have partial correlations with virtual charter school enrollment and our outcome variables that are at least several times stronger than family income to account for the differences we find (Frank 2000; 2013), our results should be understood as providing descriptive evidence rather than as strictly causal estimates.

Figure 1a documents that students who attended virtual charter schools as 9th graders have worse academic and labor market outcomes than similar students who attended traditional public schools. We find that virtual charter attendance was associated with a decrease in high school graduation (13.9 percentage points), college enrollment (8.4 percentage points), and being employed 6 years after high school (at age 24; 10.2 percentage points). Conditional on being

employed, our model estimates that virtual charter school students earn 17 percent less than similar students attending traditional schools. Figure 1b reports additional analyses for the subset of students for whom we are able to examine postsecondary degree attainment and 8-year post-high school (age 26) labor market outcomes. We find that virtual charter school students are less likely to receive a bachelor's degree (4.5 percent points). Our labor market outcomes from students eight years post-high school are similar to the six-year outcomes, with virtual charter school students 5.4 percentage points less likely to be formally employed; among those who were employed, virtual charter school students earned 19 percent less.

[Insert Figure 1 about here.]

Discussion

In providing first-of-their-kind estimates of how virtual school students fare as young adults, we add to the growing literature on the effectiveness of virtual charter schools. Consistent with the previous literature that found negative associations between virtual charter attendance and short-term academic achievement, we find that virtual charter students have substantially worse high school graduation rates (cf. Ahn and McEachin 2017; Bueno 2020), college enrollment rates, bachelor's degree attainment, formal employment rates, and earnings among those who are employed. Although there is growing interest in and demand for virtual charter schools, especially since the beginning of the pandemic, our results underscore the potential long-term negative consequences of naively meeting this demand.

Material and Methods

Data

We use data from the Oregon Department of Education and the Internal Revenue Service (IRS) housed at the U.S. Census Bureau. To link records across these files, the Census Bureau assigned unique protected identification keys (PIKs) to the relevant datasets (Wagner & Layne 2014). Using personally identifiable information available in the source files, PIKs were assigned to roughly 96 percent of the educational records and nearly 99 percent of the IRS records.

Our education data contain detailed information about student demographic characteristics such as gender, economic disadvantage, native language, race/ethnicity, special education status, gifted status; and student outcomes including high school degree attainment, post-secondary enrollment, and post-secondary degree attainment. We link these data with IRS records containing information on the family income of students when they were in 8^{th} grade (i.e., the adjusted gross income from IRS 1040s that listed students as dependents), as well as their formal employment status as young adults (i.e., the presence of a W-2) and their young adult earnings from formal employment (earnings summed across all W-2's).

Method

Prior research on charter schools has utilized a variety of approaches ranging from designs that account for selection on observables (e.g., regression, propensity score matching, or propensity score weighting) to designs that take advantage of random assignment at oversubscribed schools with waitlists (see Cohodes and Parham 2021 for a review). As virtual schools lack many of the constraints that create waitlists (e.g., space constraints imposed by physical school buildings),

research using randomization into virtual schools has not been possible, and prior evaluations of virtual schools have used selection-on-observable methods (e.g. Ahn and McEachin, 2017; CREDO, 2015; Fitzpatrick et al, 2020).

These designs have implications for both the internal validity of the comparisons of students attending different types of schools and the external validity (i.e., generalizability) of the study for designing school choice policies. In the school choice literature, random assignment designs isolate the causal impact of a given type of school, often at the cost of focusing on students interested in oversubscribed schools. It is unclear how the results from these studies generalize to other students or to schools where demand does not exceed supply. On the other hand, selection-on-observable designs cannot rule out the existence of selection on unobserved characteristics.

We follow prior research on virtual schools in taking a selection-on-observables approach, and conduct supplemental analyses following Frank (2000; 2013) that suggest that unobserved characteristics are unlikely to account for the differences we find (see Appendix Tables 3 and 4). Using our detailed data on students, we generate weights and estimate differences in outcomes that follow the logic of average treatment on the treated (ATT) differences, where the primary treatment of interest is defined as attending virtual charter schools in 9th grade and the primary counterfactual is defined as attending brick-and-mortar traditional public schools. In the supplemental materials, we also estimate and report the ATT-style differences between students attending brick-and-mortar charter schools and those attending traditional public schools.[1]

[1] Brick-and-mortar schools that change status between being traditional public schools and charter schools are excluded from our analytic sample.

We apply TWANG (Toolkit for Weighting and Analysis of Nonequivalent Groups; Ridgeway et al., 2017), which is a machine learning algorithm that utilizes gradient boosted models to iteratively generate propensity scores and corresponding weights. To calculate our ATT-style estimand, the comparison group individuals are weighted by their conditional odds of being in treatment and treatment group individuals are assigned a weight of 1. The boosted model converges on a set of weights that minimize group differences on specified pre-treatment characteristics. We use this algorithm to balance the treatment and comparison groups on 8th grade school fixed effects, student demographics, attendance, academic achievement, and log transformed family income during 8th grade.[2]

We then use the weights to estimate the ATT-style differences with a doubly robust estimator as in equation (1),

$$\text{Outcome}_i = \beta_0 + \beta_1 Treat_i + \theta \boldsymbol{X}_i + \alpha_s + \gamma_c + \varepsilon_i, \qquad (1)$$

where β_1 is the parameter of interest estimating the ATT on a given outcome for individual i in cohort c who attended school s in 8th grade, $\mathbf{X}$ represents a vector of pre-treatment covariates listed in Table 1 that improve the precision of β_1, α_s represents a series of 8th grade school fixed effects, γ_c represents a series of cohort fixed effects, and ε_i is an error term. Interpreting β_1 as a causal estimate requires a strong ignorability assumption that treatment is unrelated to the error term conditional on the propensity score-based weights (Rosenbaum and Rubin, 1983). Even

[2] We also generate alternative analytic weights using the same set of covariates but without 8th-grade school fixed effects, and present our ATT-style estimates using both set of weights in Appendix Tables 1 and 2. Additional analyses (not shown), adjusted for 8th grade neighborhood (using census tract fixed effects) as well as 8th grade school fixed effects; results were not sensitive to this adjustment.

with our unusually rich set of administrative data, this assumption is likely violated. As such, although supplemental analyses following Frank (2000; 2013) suggest that unobserved characteristics are unlikely to account for the differences we find (see Appendix Tables 3 and 4), we nonetheless interpret β_1 as providing important descriptive evidence about the differences between those who attended virtual schools in 9th grade and their observationally similar peers from the same school in 8th grade.[3]

To examine the long-term outcomes related to virtual charter school attendance, we focus on students in brick-and-mortar 8th grade schools who entered 9th grade between 2005-06 and 2010-11. This includes the earliest cohort of students that we have 8th grade characteristics for and the latest cohort with formal earnings information 6 years after high school in 2020. We index "after high school" to mean after 4 years of high school. We have higher education data through the 2016-17 academic years so we can observe who enrolls in college within 6 years after high school for everyone in this sample. For a smaller set of cohorts that start high school between 2005-06 and 2008-09, we are able to additionally observe whether students attain an associate's degree within 3 years or a bachelor's degree within 5 years after high school; for these cohorts we also observe formal earnings 8 years following high school.[4]

The earliest outcome that we examine in our analysis is whether students earn a high school

[3] We also report results from supplemental models that do not include school fixed effects in the Appendix; these models provide results that are similar to our primary specification.

[4] Comparing our results across these two sets of cohorts allows us to see whether there is any evidence that the quality of virtual charter schools may have improved over time. Examining the outcomes that we have for both sets of cohorts in Figure 1a) and 1b), we see that adding the 2009-10 and 2010-11 cohorts leads to mixed changes suggesting that the more recent cohorts have somewhat smaller gaps in high school degree attainment and wages but larger gaps in college enrollment and employment. In supplemental analyses examining smaller sets of cohorts over time (not shown), we do not find evidence that quality of virtual charter schools has improved over time, and if anything the differences that favor traditional public school students are more pronounced in more recent cohorts.

diploma or GED (General Education Development). We exclude from this measure a small proportion of students who exit the public school system because they transferred to a private school, moved out of the state, or passed away. Our measure of post-secondary enrollment is whether students are ever observed in National Student Clearinghouse data. For our labor market outcomes, we examine whether an individual has a W-2 (our measure of whether they were employed in the formal economy) and conditional on employment, the total earnings from wages across all W-2's. We log transform our wage variable and follow standard conventions in interpreting β_1 as approximating the percent difference in wages for virtual charter students (i.e., a coefficient of -.17 indicates that virtual charter students earn approximately 17 percent less than observationally similar students who attended traditional schools).

We also estimate the ATT of attending virtual charters compared to traditional schools on the probability of changing schools in the next school year (not shown). We find that virtual charter students are more likely (41 percentage points higher) to change schools, which is a substantial increase on a base rate of 16% and 25% in the unweighted and weighted comparison group, respectively.

In Appendix Table 5-8 we report additional estimates comparing brick-and-mortar charter school students to students in traditional schools. We find that students attending traditional schools fared better than students in charter schools, but that the differences between brick-and-mortar charter school students and students attending traditional public schools tend to be smaller than the differences between virtual charter students and students in traditional public schools.

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Figures and Tables

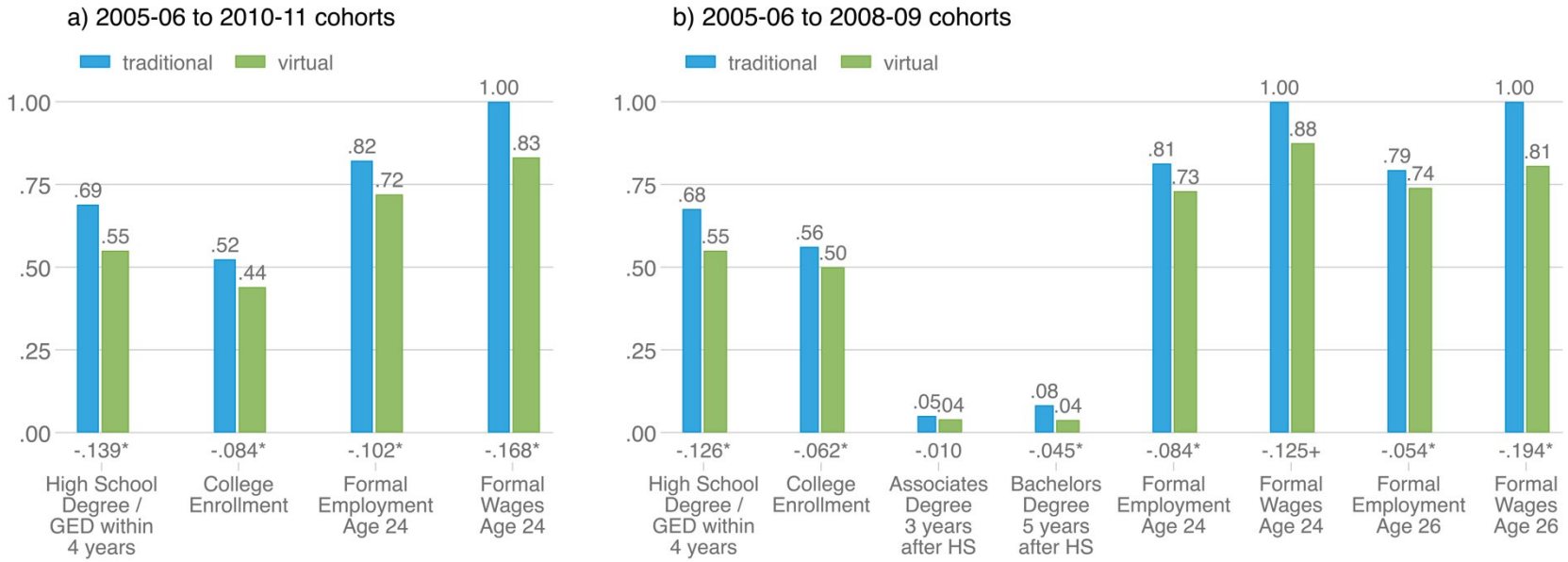

Figure 1. Young-Adult Outcomes of Students who Attended Virtual Charter Schools Compared with Similar Students in Traditional Public Schools

Note: Each green bar represents the observed average outcome of virtual charter students. Each blue bar represents the predicted average outcome of traditional public school students who have been weighted to be similar to virtual charter school students using a machine learning algorithm utilizing gradient boosted models to iteratively generate weights based on 8th grade school indicators, 8th grade test scores, family income, absences from school, race, gender, other student characteristics shown in Table 1 (calculated by differencing the doubly robust estimate of group differences from the weighted mean of virtual charter students). Differences between groups from doubly robust propensity score models are reported above the outcome labels on the horizontal axis. High school diploma or GED attainment is measured within 4 years of starting high school, and the indicator is missing for a small proportion of students that are no longer in the public school system because they left for private schools, moved out of state, or passed away. College enrollment is an indicator of whether students enrolled in any college up through the 2016-17 school year. Wages are the sum of earnings reported on IRS W-2 forms, and are limited to those with formal employment. Wage results report approximately how many dollars virtual charter students earned for every dollar earned by traditional public school students. After high school (HS) refers to after 4 years of high school. Cohort year refers to the year students entered high school (e.g., the 2005-06 cohort started 9th grade in 2005-06). For details, see Appendix Tables 1 and 2. DRB Approval Number: CBDRB-FY23-CES014-034. Source: ODE, IRS.

* $p < .05$ + $p < .10$

Table 1. Baseline Characteristics of Treatment Virtual Charter School Students and Comparison Brick-and-Mortar Traditional School Students for 2005-06 to 2010-11 9th Grade Cohorts using Weights based on Prior Characteristics and 8th Grade School FE

Prior Characteristics	Unweighted Comparison (N=219,000) Mean (SD)	Weighted Comparison (ESS=750) Mean (SD)	Treatment (N=800) Mean (SD)	Weighted Difference (SE)	p-value
Female	.48 (.50)	.55 (.50)	.57 (.50)	.02 (.02)	.17
Economically Disadvantaged	.42 (.49)	.51 (.50)	.51 (.50)	.00 (.02)	.87
Native Language is English	.62 (.49)	.41 (.49)	.42 (.49)	.01 (.02)	.46
Hispanic	.15 (.36)	.10 (.30)	.08 (.27)	-.02* (.01)	.02
White	.73 (.45)	.81 (.39)	.83 (.37)	.02 (.01)	.11
SPED	.13 (.34)	.14 (.35)	.12 (.33)	-.02 (.01)	.12
Gifted	.11 (.31)	.07 (.25)	.06 (.23)	-.01 (.01)	.23
8th Grade Absence rate	.06 (.06)	.13 (.09)	.13 (.10)	.01 (.00)	.15
8th Grade Math	.05 (.98)	-.18 (.85)	-.20 (.80)	-.02 (.03)	.56
8th Grade Reading	.05 (.97)	-.06 (.88)	-.01 (.88)	.05 (.03)	.11
Ln(Family Income during 8th Grade)	10.93 (1.15)	10.64 (1.28)	10.59 (1.25)	-.04 (.04)	.32

Note: Each observation is a student who entered 9th grade between 2005-06 and 2010-11. Treatment students attended virtual charter schools and comparison students attended traditional public schools. Students in these cohorts that attended virtual charters in 8th grade are excluded. Weights are the conditional odds of being in treatment for comparison student and 1 for treatment students, flexibility generated using covariates and dummy indicator for the school attended in 8th grade. Weighted difference and corresponding *p*-values are estimated from regressing (via weighted OLS) the treatment indicator on student characteristics, cohort dummies, and 8th grade school dummies. Economically Disadvantaged students are eligible for free- reduced priced lunch. Math and Reading Scores are standardized within year and grade to have a mean of 0 and SD of 1 in the population. Income is inflation-adjusted prior to log transformation. Students missing family income data in 8th grade were assigned family income from 7th grade, if available, and the sample mean income otherwise. All estimates have been rounded in accordance with Census rounding rules. N=Observations. ESS= Effective Sample Size. SD= Standard deviation. SE = Standard errors. SPED = students with Special Education status. DRB Approval Number: CBDRB-FY23-CES014-034. Source: ODE, IRS.
* $p < .05$

Appendix

The appendix provides additional information about the main results, as well as results from additional analyses. The appendix tables are organized into four sections.

Section I. Outcome Estimates contains Appendix Tables 1 and 2, which provide the ATT-style estimated group differences and standard errors from a variety of model specifications. These tables also include the mean of each outcome by subgroup, weighted and unweighted. The preferred model estimates in these tables (row 6) correspond to the results presented in Figure 1.

Section II. Sensitivity Analyses contains Appendix Tables 3 and 4, which show the sensitivity of the preferred model estimates (Frank 2000; 2013). Following Frank (2013) we compute the percent of estimates that would have to be due to bias for the inference to be invalidated at the .05 alpha level. Following Frank (2000) we report the impact of potentially confounding variables necessary to invalidate inference, conditional on all observed covariates used in the model (e.g., family income, prior test score, 8th grade school attended, and demographic characteristics). Given these rich covariates, the partial correlations of additional unobserved variables are likely to be relatively small. In our main results (Figure 1, Panel A), about 40-80% of the estimated group differences, depending on the outcome, would have to be due to bias to invalidate a causal interpretation of these results. These results suggest that although we are unable to rule out selection on unobserved factors, the differences that we observe are likely attributable to virtual charter attendance.

Section III. Brick-and-Mortar Charter Analysis contains Appendix Tables 5-8, which show the baseline balance and differences in outcomes for models examining brick-and-mortar charter students compared to traditional brick-and-mortar schools.

Section IV. Baseline Balance for Alternative Specifications contains Appendix Tables 9 and 10, which show the baseline balance results using alternative specifications in the virtual charter analysis, and Appendix Tables 11-12, which show parallel baseline balance results for the brick-and-mortar charter analysis.

Appendix Section I. Outcome Estimates

Appendix Table 1. Outcomes of Students who Attended Virtual Charter Schools Compared with Similar Traditional Public School Students, 2005-06 to 2010-11 Cohorts

	High School Diploma/GED	College Enrollment	Age 24 W-2	Age 24 Ln(Wage)
Unadjusted	-.242*	-.198*	-.138*	-.276*
	(.018)	(.017)	(.016)	(.053)
Cov. & School FE	-.132*	-.085*	-.099*	-.134*
	(.018)	(.017)	(.016)	(.052)
Cov. Weights	-.152*	-.090*	-.101*	-.171*
	(.018)	(.018)	(.016)	(.054)
Doubly Robust	-.146*	-.085*	-.092*	-.158*
(Cov. Only)	(.018)	(.017)	(.016)	(.053)
Cov. & School FE Weights	-.146*	-.085*	-.107*	-.189*
	(.019)	(.018)	(.016)	(.054)
Doubly Robust	-.139*	-.084*	-.102*	-.168*
(Cov. & School FE)	(.016)	(.015)	(.014)	(.049)
Unweighted Comparison mean	.787	.635	.856	9.854
Weighted Control mean (Cov. Only)	.697	.527	.819	9.749
Weighted Control mean (Cov. & School FE)	.691	.522	.825	9.767
Unweighted Treatment mean	.550	.440	.720	9.578
N (Unweighted)	210,750	219,800	219,800	187,600

Note: Standard errors are in parentheses. Average Treatment Effect on the Treated (ATT)-style estimates are show in the bottom four rows. "Unadjusted" presents estimates from regressing the outcome on treatment and cohort dummies. "Cov & School FE" estimates additionally adjust for prior characteristics (listed in the balance table) and prior (8^{th}-grade) school fixed effects. "Cov. weights" presents estimates from regressing the outcome on treatment and cohort dummies using ATT-style weights, which are based on covariates—specifically, prior characteristics. Doubly Robust (Cov. Only) also adjusts for covariates in the weighted regression model. "Cov. & FE weights" presents estimates from regressing the outcome on treatment and cohort dummies using ATT-style weights, which are based on covariates—specifically, prior characteristics—and 8th grade school fixed effects. Doubly Robust (Cov. & FE Only) adjusts also for covariates in the weighted regression model. High school diploma or GED attainment within 4 years of starting high school is missing for a small proportion of students that are no longer in the public school system because they left for private schools, moved out of state, or passed away. College enrollment is an indicator of whether students were enrolled in any college up through the 2016-17 school year. W-2 indicates the existence of an IRS W-2 record (i.e., formal employment). Wages are the sum of W-2 earnings reported and are limited to those with formal earnings. DRB Approval Number: CBDRB-FY23-CES014-034. Source: ODE, IRS.
* $p < .05$

Appendix Table 2. Outcomes of Students who Attended Virtual Charter Schools Compared with Similar Traditional Public School Students, 2005-06 to 2008-09 Cohorts

	High School Diploma/GED	College Enrollment	AA/AS	BA/BS	Age 24 W-2	Age 24 Ln(Wage)	Age 26 W-2	Age 26 Ln(Wage)
Unadjusted	-.238*	-.171*	-.023*	-.135*	-.127*	-.267*	-.106*	-.424*
	(.025)	(.024)	(.009)	(.009)	(.021)	(.073)	(.021)	(.078)
Cov. & School FE	-.119*	-.057*	-.005	-.029*	-.081*	-.072	-.049*	-.194*
	(.024)	(.024)	(.009)	(.010)	(.022)	(.072)	(.021)	(.079)
Cov. Weights	-.155*	-.073*	-.009	-.042*	-.088*	-.166*	-.064*	-.267*
	(.025)	(.024)	(.009)	(.009)	(.021)	(.073)	(.021)	(.078)
Doubly Robust (Cov. Only)	-.141*	-.067*	-.007	-.041*	-.081*	-.161*	-.057*	-.233*
	(.023)	(.023)	(.009)	(.009)	(.021)	(.075)	(.020)	(.077)
Cov. & School FE Weights	-.138*	-.066*	-.009	-.047*	-.088*	-.166*	-.065*	-.287*
	(.025)	(.024)	(.010)	(.009)	(.021)	(.074)	(.021)	(.079)
Doubly Robust (Cov. & School FE)	-.126*	-.062*	-.010	-.045*	-.084*	-.125+	-.054*	-.194*
	(.020)	(.020)	(.009)	(.007)	(.019)	(.067)	(.018)	(.056)
Unweighted Comparison mean	.792	.669	.063	.173	.856	9.824	.841	10.050
Weighted Control mean (Cov. Only)	.709	.571	.050	.081	.817	9.723	.799	9.890
Weighted Control mean (Cov. & School FE)	.692	.564	.049	.086	.817	9.723	.800	9.910
Unweighted Treatment mean	.550	.500	.040	.038	.730	9.557	.740	9.623
N (Unweighted)	142,400	147,450	147,450	147,450	147,450	126,350	147,450	124,350

Note: Standard errors are in parentheses. Average Treatment Effect on the Treated (ATT)-style estimates are show in the bottom four rows. "Unadjusted" presents estimates from regressing the outcome on treatment and cohort dummies. "Cov & School FE" estimates additionally adjust for prior characteristics (listed in the balance table) and prior (8^{th}-grade) school fixed effects. "Cov. weights" presents estimates from regressing the outcome on treatment and cohort dummies using ATT-style weights, which are based on covariates—specifically, prior characteristics. Doubly Robust (Cov. Only) also adjusts for covariates in the weighted regression model. "Cov. & FE weights" presents estimates from regressing the outcome on treatment and cohort dummies using ATT-style weights, which are based on covariates—specifically, prior characteristics—and 8th grade 8^{th}-grade school fixed effects. Doubly Robust (Cov. & FE Only) adjusts also for covariates in the weighted regression model. High school diploma or GED attainment within 4 years of starting high school is missing for a small proportion of students that are no longer in the public school system because they left for private schools, moved out of state, or passed away. College enrollment is an indicator of whether students were enrolled in any college up through the 2016-17 school year. AA/AS and BA/BS is an indicator of whether students obtained the respective degrees by the 2016-17 school year. W-2 indicates the existence of an IRS W-2 record (i.e., formal employment). Wages are the sum of W-2 earnings reported and are limited to those with formal earnings. DRB Approval Number: CBDRB-FY23-CES014-034. Source: ODE, IRS.

* $p < .05$

Appendix Section II. Sensitivity Analyses

Appendix Table 3. Sensitivity Analysis: Outcomes of Students who Attended Virtual Charter Schools Compared with Similar Traditional Public School Students, 2005-06 to 2010-11 Cohorts

	High School Diploma/GED	College Enrollment	Age 24 W-2	Age 24 Ln(Wage)
Estimates from Figure 1				
Doubly Robust	-.139*	-.084*	-.102*	-.168*
(Cov. & School FE)	(.016)	(.015)	(.014)	(.049)
Sensitivity Analysis				
% Bias needed	77%	65%	73%	42%
Partial correlation needed	.146	.108	.130	.068
N (Unweighted)	210,750	219,800	219,800	187,600

Note: Standard errors are in parentheses. Average Treatment Effect on the Treated (ATT)-style estimates from our preferred model using the 2005-06 to 2010-11 cohorts are show in the first row. The next two rows show the results of Frank (2013) and Frank (2000) sensitivity analyses, respectively. We follow Frank (2013) in reporting "% Bias needed" to show the percent of the doubly robust estimates that would have to be due to bias for the inference to be invalidated at the .05 alpha level. The larger the percentage presented, the more robust the estimate. We follow Frank (2000) in reporting "Partial correlation needed" to show the absolute value of the correlation between an unobserved confounder and treatment (virtual charter attendance) and the symmetrical level of partial correlation between the unobserved confounder and the outcome necessary to invalidate an inference for a null hypothesis of 0 effect at the .05 alpha level, conditional on all observed covariates used in the model (e.g., family income). DRB Approval Number: CBDRB-FY23-CES014-034. Source: ODE, IRS.

Appendix Table 4. Sensitivity Analysis: Outcomes of Students who Attended Virtual Charter Schools Compared with Similar Traditional Public School Students, 2005-06 to 2008-09 Cohorts

	High School Diploma/GED	College Enrollment	AA/AS	BA/BS	Age 24 W-2	Age 24 Ln(Wage)	Age 26 W-2	Age 26 Ln(Wage)
Estimates from Figure 1								
Doubly Robust	-.126*	-.062*	-.010	-.045*	-.084*	-.125+	-.054*	-.194*
(Cov. & School FE)	(.020)	(.020)	(.009)	(.007)	(.019)	(.067)	(.018)	(.056)
Sensitivity Analysis								
% Bias needed	69%	37%	N/A	70%	56%	5%	35%	43%
Partial Correlation needed	.118	.060	N/A	.119	.089	.017	.058	.069
N (Unweighted)	142,400	147,450	147,450	147,450	147,450	126,350	147,450	124,350

Note: Standard errors are in parentheses. Average Treatment Effect on the Treated (ATT)-style estimates from our preferred model using the 2005-06 to 2008-09 cohorts are show in the first row. The next two rows show the results of Frank (2013) and Frank (2000) sensitivity analyses, respectively. We follow Frank (2013) in reporting "% Bias needed" to show the percent of the doubly robust estimates that would have to be due to bias for the inference to be invalidated at the .05 alpha level. The larger the percentage presented, the more robust the estimate. We follow Frank (2000) in reporting "Partial correlation needed" to show the absolute value of the correlation between an unobserved confounder and treatment (virtual charter attendance) and the symmetrical level of partial correlation between the unobserved confounder and the outcome necessary to invalidate an inference for a null hypothesis of 0 effect at the .05 alpha level, conditional on all observed covariates used in the model (e.g., family income). DRB Approval Number: CBDRB-FY23-CES014-034. Source: ODE, IRS.

Appendix Section III. Brick-and-Mortar Charter Analysis

Appendix Table 5. Baseline Characteristics of Treatment Brick-and-Mortar Charter School Students and Comparison Brick-and-Mortar Traditional School Students for 2005-06 to 2010-11 9th Grade Cohorts using Weights based on Prior Characteristics and 8th Grade School FE

Prior Characteristics	Unweighted Comparison (N=219,000) Mean (SD)	Weighted Comparison (ESS=1,700) Mean (SD)	Treatment (N=1,800) Mean (SD)	Weighted Difference (SE)	*p*-value
Female	.48 (.50)	.49 (.50)	.50 (.50)	.00 (.01)	.89
Economically Disadvantaged	.42 (.49)	.52 (.50)	.52 (.50)	-.00 (.01)	.94
Native Language is English	.62 (.49)	.51 (.50)	.49 (.50)	-.02 (.01)	.10
Hispanic	.15 (.36)	.10 (.30)	.09 (.28)	-.01 (.01)	.16
White	.73 (.45)	.76 (.43)	.77 (.42)	.01 (.01)	.50
SPED	.13 (.34)	.17 (.37)	.16 (.36)	-.01 (.01)	.25
Gifted	.11 (.31)	.06 (.24)	.06 (.23)	-.01 (.01)	.20
8th Grade Absence rate	.06 (.06)	.10 (.09)	.10 (.09)	.00 (.00)	.65
8th Grade Math	.05 (.98)	-.22 (.90)	-.24 (.90)	-.02 (.02)	.37
8th Grade Reading	.05 (.97)	-.12 (.95)	-.10 (.97)	.02 (.02)	.48
Ln(Family Income during 8th Grade)	10.93 (1.15)	10.60 (1.29)	10.58 (1.26)	-.02 (.03)	.63

Note: Each observation is a student who entered 9th grade between 2005-06 and 2010-11. Treatment students attended brick-and-mortar charter schools and comparison students attended traditional public schools. Students in these cohorts that attended brick-and-mortar charters in 8th grade are excluded. Weights are the conditional odds of being in treatment for comparison student and 1 for treatment students, flexibility generated using covariates and dummy indicator for the school attended in 8th grade. Weighted difference and corresponding *p*-values are estimated from regressing (via weighted OLS) the treatment indicator on student characteristics, cohort dummies, and 8th grade prior school dummies. Economically Disadvantaged students are eligible for free- reduced priced lunch. Math and Reading Scores are standardized within year and grade to have a mean of 0 and SD of 1 in the population. Income is inflation-adjusted prior to log transformation. Students missing family income data in 8th grade were assigned family income from 7th grade, if available, and the sample mean income otherwise. All estimates have been rounded in accordance with Census rounding rules. N=Observations. ESS= Effective Sample Size. SD= Standard deviation. SE = Standard errors. SPED = students with Special Education status. DRB Approval Number: CBDRB-FY23-CES014-034. Source: ODE, IRS.
* $p < .05$

Appendix Table 6. Outcomes of Students who Attended Brick-and-Mortar Charter Schools Compared with Similar Traditional Public School Students, 2005-06 to 2010-11 Cohorts

	High School Diploma/GED	College Enrollment	Age 24 W-2	Age 24 Ln(Wage)
Unadjusted	-.188*	-.125*	-.059*	-.230*
	(.012)	(.012)	(.009)	(.034)
Cov. & School FE	-.077*	-.031*	-.034*	-.127*
	(.011)	(.011)	(.010)	(.033)
Cov. Weights	-.099*	-.024*	-.029*	-.125*
	(.012)	(.012)	(.010)	(.034)
Doubly Robust (Cov. Only)	-.096*	-.020+	-.029*	-.118*
	(.011)	(.011)	(.009)	(.032)
Cov. & School FE Weights	-.069*	-.028*	-.033*	-.132*
	(.012)	(.012)	(.010)	(.035)
Doubly Robust (Cov. & School FE)	-.069*	-.026*	-.032*	-.127*
	(.011)	(.011)	(.009)	(.032)
Unweighted Comparison mean	.787	.635	.856	9.854
Weighted Control mean (Cov. Only)	.698	.534	.827	9.749
Weighted Control mean (Cov. & School FE)	.668	.538	.830	9.756
Unweighted Treatment mean	.599	.511	.797	9.624
N (Unweighted)	211,700	220,800	220,800	188,400

Note: Standard errors are in parentheses. Average Treatment Effect on the Treated (ATT)-style estimates are show in the bottom four rows. "Unadjusted" presents estimates from regressing the outcome on treatment and cohort dummies. "Cov & School FE" estimates additionally adjust for prior characteristics (listed in the balance table) and prior (8^{th}-grade) school fixed effects. "Cov. weights" presents estimates from regressing the outcome on treatment and cohort dummies using ATT-style weights, which are based on covariates—specifically, prior characteristics. Doubly Robust (Cov. Only) also adjusts for covariates in the weighted regression model. "Cov. & FE weights" presents estimates from regressing the outcome on treatment and cohort dummies using ATT-style weights, which are based on covariates—specifically, prior characteristics—and 8th grade school fixed effects. Doubly Robust (Cov. & FE Only) adjusts also for covariates in the weighted regression model. High school diploma or GED attainment within 4 years of starting high school is missing for a small proportion of students that are no longer in the public school system because they left for private schools, moved out of state, or passed away. College enrollment is an indicator of whether students were enrolled in any college up through the 2016-17 school year. W-2 indicates the existence of an IRS W-2 record (i.e., formal employment). Wages are the sum of W-2 earnings reported and are limited to those with formal earnings. DRB Approval Number: CBDRB-FY23-CES014-034. Source: ODE, IRS.

* $p < .05$

Appendix Table 7. Baseline Characteristics of Treatment Brick-and-Mortar Charter School Students and Comparison Brick-and-Mortar Traditional School Students for 2005-06 to 2008-09 9th Grade Cohorts using Weights based on Prior Characteristics and 8th Grade School FE

Prior Characteristics	Unweighted Comparison (N=147,000) Mean (SD)	Weighted Comparison (ESS=1,000) Mean (SD)	Treatment (N=1,100) Mean (SD)	Weighted Difference (SE)	*p*-value
Female	.48 (.50)	.50 (.50)	.51 (.50)	.02 (.02)	.29
Economically Disadvantaged	.40 (.49)	.50 (.50)	.49 (.50)	-.01 (.02)	.57
Native Language is English	.82 (.39)	.77 (.42)	.77 (.42)	-.00 (.01)	.84
Hispanic	.14 (.35)	.10 (.30)	.09 (.28)	-.01 (.01)	.14
White	.74 (.44)	.76 (.43)	.77 (.42)	.01 (.01)	.49
SPED	.13 (.34)	.16 (.36)	.14 (.35)	-.02 (.01)	.18
Gifted	.11 (.31)	.06 (.25)	.06 (.24)	-.01 (.01)	.46
8th Grade Absence rate	.06 (.06)	.10 (.09)	.11 (.09)	.00 (.00)	.18
8th Grade Math	.06 (.98)	-.23 (.92)	-.26 (.91)	-.03 (.03)	.34
8th Grade Reading	.05 (.97)	-.13 (.96)	-.12 (.98)	.01 (.03)	.80
Ln(Family Income during 8th Grade)	10.96 (1.15)	10.63 (1.32)	10.61 (1.30)	-.02 (.04)	.59

Note: Each observation is a student who entered 9th grade between 2005-06 and 2008-09. Treatment students attended brick-and-mortar charter schools and comparison students attended traditional public schools. Students in these cohorts that attended brick-and-mortar charters in 8th grade are excluded. Weights are the conditional odds of being in treatment for comparison student and 1 for treatment students, flexibility generated using covariates and dummy indicator for the school attended in 8th grade. Weighted difference and corresponding *p*-values are estimated from regressing (via weighted OLS) the treatment indicator on student characteristics, cohort dummies, and 8th grade prior school dummies. Economically Disadvantaged students are eligible for free- reduced priced lunch. Math and Reading Scores are standardized within year and grade to have a mean of 0 and SD of 1 in the population. Income is inflation-adjusted prior to log transformation. Students missing family income data in 8th grade were assigned family income from 7th grade, if available, and the sample mean income otherwise. All estimates have been rounded in accordance with Census rounding rules. N=Observations. ESS= Effective Sample Size. SD= Standard deviation. SE = Standard errors. SPED = students with Special Education status. DRB Approval Number: CBDRB-FY23-CES014-034. Source: ODE, IRS.

* $p < .05$

Appendix Table 8. Outcomes of Students who Attended Brick-and-Mortar Charter Schools Compared with Similar Traditional Public School Students, 2005-06 to 2008-09 Cohorts

	High School Diploma/GED	College Enrollment	AA/AS	BA/BS	Age 24 W-2	Age 24 Ln(Wage)	Age 26 W-2	Age 26 Ln(Wage)
Unadjusted	-.191*	-.111*	-.022*	-.113*	-.077*	-.239*	-.066*	-.295*
	(.015)	(.015)	(.006)	(.007)	(.013)	(.045)	(.013)	(.046)
Cov. & School FE	-.068*	-.028*	-.009	-.025*	-.051*	-.128*	-.035*	-.161*
	(.015)	(.014)	(.006)	(.008)	(.013)	(.044)	(.013)	(.046)
Cov. Weights	-.098*	-.018	-.008	-.037*	-.048*	-.122*	-.034*	-.155*
	(.015)	(.015)	(.006)	(.007)	(.013)	(.045)	(.013)	(.047)
Doubly Robust	-.096*	-.015	-.008	-.034*	-.046*	-.108*	-.033*	-.148*
(Cov. Only)	(.014)	(.014)	(.006)	(.007)	(.013)	(.042)	(.013)	(.045)
Cov. & School FE Weights	-.063*	-.024	-.009	-.033*	-.053*	-.131*	-.035*	-.169*
	(.016)	(.016)	(.006)	(.008)	(.013)	(.047)	(.013)	(.048)
Doubly Robust	-.056*	-.023+	-.009	-.031*	-.050*	-.111*	-.031*	-.165*
(Cov. & School FE)	(.014)	(.014)	(.006)	(.007)	(.012)	(.041)	(.012)	(.042)
Unweighted Comparison mean	.792	.669	.063	.173	.856	9.824	.841	10.050
Weighted Control mean (Cov. Only)	.700	.576	.050	.097	.826	9.707	.810	9.907
Weighted Control mean (Cov. & School FE)	.664	.582	.051	.094	.832	9.715	.811	9.920
Unweighted Treatment mean	.601	.558	.042	.061	.779	9.585	.776	9.751
N (Unweighted)	143,000	148,100	148,100	148,100	148,100	126,800	148,100	124,800

Note: Standard errors are in parentheses. Average Treatment Effect on the Treated (ATT)-style estimates are show in the bottom four rows. "Unadjusted" presents estimates from regressing the outcome on treatment and cohort dummies. "Cov & School FE" estimates additionally adjust for prior characteristics (listed in the balance table) and prior (8^{th}-grade) school fixed effects. "Cov. weights" presents estimates from regressing the outcome on treatment and cohort dummies using ATT-style weights, which are based on covariates—specifically, prior characteristics. Doubly Robust (Cov. Only) also adjusts for covariates in the weighted regression model. "Cov. & FE weights" presents estimates from regressing the outcome on treatment and cohort dummies using ATT-style weights, which are based on covariates—specifically, prior characteristics—and 8th grade school fixed effects. Doubly Robust (Cov. & FE Only) adjusts also for covariates in the weighted regression model. High school diploma or GED attainment within 4 years of starting high school is missing for a small proportion of students that are no longer in the public school system because they left for private schools, moved out of state, or passed away. College enrollment is an indicator of whether students were enrolled in any college up through the 2016-17 school year. AA/AS and BA/BS is an indicator of whether students obtained the respective degrees by the 2016-17 school year. W-2 indicates the existence of an IRS W-2 record (i.e., formal employment). Wages are the sum of W-2 earnings reported and are limited to those with formal earnings. DRB Approval Number: CBDRB-FY23-CES014-034. Source: ODE, IRS.

* $p < .05$

Appendix Section IV. Baseline Balance for Alternative Specifications

Appendix Table 9. Baseline Characteristics of Treatment Virtual Charter School Students and Comparison Brick-and-Mortar Traditional School Students for 2005-06 to 2010-11 9th Grade Cohorts using Weights based on Prior Characteristics

Prior Characteristics	Unweighted Comparison (N=219,000) Mean (SD)	Weighted Comparison (ESS=800) Mean (SD)	Treatment (N=800) Mean (SD)	Weighted Difference (SE)	*p*-value
Female	.48 (.50)	.56 (.50)	.57 (.50)	.01 (.02)	.51
Economically Disadvantaged	.42 (.49)	.51 (.50)	.51 (.50)	.00 (.02)	.88
Native Language is English	.62 (.49)	.40 (.49)	.42 (.49)	.02 (.02)	.17
Hispanic	.15 (.36)	.09 (.28)	.08 (.27)	-.01 (.01)	.31
White	.73 (.45)	.83 (.38)	.83 (.37)	.00 (.01)	.74
SPED	.13 (.34)	.13 (.34)	.12 (.33)	-.01 (.01)	.50
Gifted	.11 (.31)	.07 (.25)	.06 (.23)	-.01 (.01)	.36
8th Grade Absence rate	.06 (.06)	.13 (.09)	.13 (.10)	.01 (.00)	.11
8th Grade Math	.05 (.98)	-.19 (.81)	-.20 (.80)	-.01 (.03)	.71
8th Grade Reading	.05 (.97)	-.01 (.86)	-.01 (.88)	.00 (.03)	.92
Ln(Family Income during 8th Grade)	10.93 (1.15)	10.61 (1.24)	10.59 (1.25)	-.02 (.04)	.73

Note: Each observation is a student who entered 9th grade between 2005-06 and 2010-11. Treatment students attended virtual charter schools and comparison students attended traditional public schools. Students in these cohorts that attended virtual charters in 8th grade are excluded. Weights are the conditional odds of being in treatment for comparison student and 1 for treatment students, flexibility generated using covariates and dummy indicator for the school attended in 8th grade. Weighted difference and corresponding *p*-values are estimated from regressing (via weighted OLS) the treatment indicator on student characteristics and cohort dummies. Economically Disadvantaged students are eligible for free- reduced priced lunch. Math and Reading Scores are standardized within year and grade to have a mean of 0 and SD of 1 in the population. Income is inflation-adjusted prior to log transformation. Students missing family income data in 8th grade were assigned family income from 7th grade, if available, and the sample mean income otherwise. All estimates have been rounded in accordance with Census rounding rules. N=Observations. ESS= Effective Sample Size. SD= Standard deviation. SE = Standard errors. SPED = students with Special Education status. DRB Approval Number: CBDRB-FY23-CES014-034. Source: ODE, IRS.
* $p < .05$

Appendix Table 10. Baseline Characteristics of Treatment Virtual Charter School Students and Comparison Brick-and-Mortar Traditional School Students for 2005-06 to 2008-09 9th Grade Cohorts using Weights based on Prior Characteristics and 8th Grade School FE

Prior Characteristics	Unweighted Comparison (N=147,000) Mean (SD)	Weighted Comparison (ESS=400) Mean (SD)	Treatment (N=450) Mean (SD)	Weighted Difference (SE)	*p*-value
Female	.48 (.50)	.54 (.50)	.58 (.49)	.03 (.02)	.17
Economically Disadvantaged	.40 (.49)	.49 (.50)	.48 (.50)	-.01 (.02)	.65
Native Language is English	.82 (.39)	.62 (.49)	.60 (.49)	-.01 (.02)	.57
Hispanic	.14 (.35)	.10 (.30)	.07 (.26)	-.03* (.01)	.04
White	.74 (.44)	.80 (.40)	.84 (.37)	.03+ (.02)	.05
SPED	.13 (.34)	.15 (.36)	.13 (.34)	-.02 (.02)	.17
Gifted	.11 (.31)	.07 (.25)	.05 (.22)	-.02 (.01)	.15
8th Grade Absence rate	.06 (.06)	.12 (.10)	.13 (.10)	.01 (.00)	.25
8th Grade Math	.06 (.98)	-.17 (.86)	-.21 (.79)	-.03 (.04)	.42
8th Grade Reading	.05 (.97)	-.09 (.91)	-.02 (.89)	.07 (.04)	.11
Ln(Family Income during 8th Grade)	10.96 (1.15)	10.61 (1.43)	10.57 (1.34)	-.04 (.07)	.55

Note: Each observation is a student who entered 9th grade between 2005-06 and 2008-09. Treatment students attended virtual charter schools and comparison students attended traditional public schools. Students in these cohorts that attended virtual charters in 8th grade are excluded. Weights are the conditional odds of being in treatment for comparison student and 1 for treatment students, flexibility generated using covariates and dummy indicator for the school attended in 8th grade. Weighted difference and corresponding *p*-values are estimated from regressing (via weighted OLS) the treatment indicator on student characteristics, cohort dummies, and 8th grade school dummies. Economically Disadvantaged students are eligible for free- reduced priced lunch. Math and Reading Scores are standardized within year and grade to have a mean of 0 and SD of 1 in the population. Income is inflation-adjusted prior to log transformation. Students missing family income data in 8th grade were assigned family income from 7th grade, if available, and the sample mean income otherwise. All estimates have been rounded in accordance with Census rounding rules. N=Observations. ESS= Effective Sample Size. SD= Standard deviation. SE = Standard errors. SPED = students with Special Education status. DRB Approval Number: CBDRB-FY23-CES014-034. Source: ODE, IRS.
* p < .05

Appendix Table 11. Baseline Characteristics of Treatment Virtual Charter School Students and Comparison Brick-and-Mortar Traditional School Students for 2005-06 to 2008-09 9th Grade Cohorts using Weights based on Prior Characteristics

Prior Characteristics	Unweighted Comparison (N=147,000) Mean (SD)	Weighted Comparison (ESS=400) Mean (SD)	Treatment (N=450) Mean (SD)	Weighted Difference (SE)	*p*-value
Female	.48 (.50)	.57 (.50)	.58 (.49)	.01 (.02)	.68
Economically Disadvantaged	.40 (.49)	.48 (.50)	.48 (.50)	-.00 (.02)	.92
Native Language is English	.82 (.39)	.61 (.49)	.60 (.49)	-.00 (.02)	.89
Hispanic	.14 (.35)	.08 (.28)	.07 (.26)	-.01 (.01)	.32
White	.74 (.44)	.83 (.37)	.84 (.37)	.01 (.02)	.74
SPED	.13 (.34)	.13 (.34)	.13 (.34)	-.00 (.02)	.94
Gifted	.11 (.31)	.06 (.24)	.05 (.22)	-.01 (.01)	.35
8th Grade Absence rate	.06 (.06)	.12 (.09)	.13 (.10)	.01 (.00)	.13
8th Grade Math	.06 (.98)	-.18 (.78)	-.21 (.79)	-.03 (.04)	.49
8th Grade Reading	.05 (.97)	-.01 (.87)	-.02 (.89)	-.01 (.04)	.77
Ln(Family Income during 8th Grade)	10.96 (1.15)	10.59 (1.26)	10.57 (1.34)	-.03 (.06)	.67

Note: Each observation is a student who entered 9th grade between 2005-06 and 2008-09. Treatment students attended virtual charter schools and comparison students attended traditional public schools. Students in these cohorts that attended virtual charters in 8th grade are excluded. Weights are the conditional odds of being in treatment for comparison student and 1 for treatment students, flexibility generated using covariates and dummy indicator for the school attended in 8th grade. Weighted difference and corresponding *p*-values are estimated from regressing (via weighted OLS) the treatment indicator on student characteristics and cohort dummies. Economically Disadvantaged students are eligible for free- reduced priced lunch. Math and Reading Scores are standardized within year and grade to have a mean of 0 and SD of 1 in the population. Income is inflation-adjusted prior to log transformation. Students missing family income data in 8th grade were assigned family income from 7th grade, if available, and the sample mean income otherwise. All estimates have been rounded in accordance with Census rounding rules. N=Observations. ESS= Effective Sample Size. SD= Standard deviation. SE = Standard errors. SPED = students with Special Education status. DRB Approval Number: CBDRB-FY23-CES014-034. Source: ODE, IRS.

* $p < .05$

Appendix Table 12. Baseline Characteristics of Treatment Brick-and-Mortar Charter School Students and Comparison Brick-and-Mortar Traditional School Students for 2005-06 to 2010-11 9th Grade Cohorts using Weights based on Prior Characteristics

Prior Characteristics	Unweighted Comparison (N=219,000) Mean (SD)	Weighted Comparison (ESS=1,800) Mean (SD)	Treatment (N=1,800) Mean (SD)	Weighted Difference (SE)	*p*-value
Female	.48 (.50)	.50 (.50)	.50 (.50)	-.00 (.01)	.96
Economically Disadvantaged	.42 (.49)	.52 (.50)	.52 (.50)	.00 (.01)	.75
Native Language is English	.62 (.49)	.52 (.50)	.49 (.50)	-.03* (.01)	.01
Hispanic	.15 (.36)	.09 (.29)	.09 (.28)	-.01 (.01)	.36
White	.73 (.45)	.77 (.42)	.77 (.42)	.00 (.01)	.66
SPED	.13 (.34)	.16 (.37)	.16 (.36)	-.01 (.01)	.53
Gifted	.11 (.31)	.06 (.24)	.06 (.23)	-.00 (.01)	.36
8th Grade Absence rate	.06 (.06)	.10 (.08)	.10 (.09)	.00 (.00)	.28
8th Grade Math	.05 (.98)	-.23 (.90)	-.24 (.90)	-.01 (.02)	.62
8th Grade Reading	.05 (.97)	-.11 (.96)	-.10 (.97)	.00 (.02)	.86
Ln(Family Income during 8th Grade)	10.93 (1.15)	10.59 (1.28)	10.58 (1.26)	-.01 (.03)	.82

Note: Each observation is a student who entered 9th grade between 2005-06 and 2010-11. Treatment students attended brick-and-mortar charter schools and comparison students attended traditional public schools. Students in these cohorts that attended brick-and-mortar charters in 8th grade are excluded. Weights are the conditional odds of being in treatment for comparison student and 1 for treatment students, flexibility generated using covariates and dummy indicator for the school attended in 8th grade. Weighted difference and corresponding *p*-values are estimated from regressing (via weighted OLS) the treatment indicator on student characteristics and cohort dummies. Economically Disadvantaged students are eligible for free- reduced priced lunch. Math and Reading Scores are standardized within year and grade to have a mean of 0 and SD of 1 in the population. Income is inflation-adjusted prior to log transformation. Students missing family income data in 8th grade were assigned family income from 7th grade, if available, and the sample mean income otherwise. All estimates have been rounded in accordance with Census rounding rules. N=Observations. ESS= Effective Sample Size. SD= Standard deviation. SE = Standard errors. SPED = students with Special Education status. DRB Approval Number: CBDRB-FY23-CES014-034. Source: ODE, IRS.
* $p < .05$

Appendix Table 13. Baseline Characteristics of Treatment Brick-and-Mortar Charter School Students and Comparison Brick-and-Mortar Traditional School Students for 2005-06 to 2008-09 9th Grade Cohorts using Weights based on Prior Characteristics

Prior Characteristics	Unweighted Comparison (N=147,000) Mean (SD)	Weighted Comparison (ESS=1,000) Mean (SD)	Treatment (N=1,100) Mean (SD)	Weighted Difference (SE)	*p*-value
Female	.48 (.50)	.50 (.50)	.51 (.50)	.01 (.02)	.51
Economically Disadvantaged	.40 (.49)	.50 (.50)	.49 (.50)	-.01 (.02)	.70
Native Language is English	.82 (.39)	.78 (.41)	.77 (.42)	-.01 (.01)	.28
Hispanic	.14 (.35)	.09 (.29)	.09 (.28)	-.01 (.01)	.39
White	.74 (.44)	.77 (.42)	.77 (.42)	.00 (.01)	.76
SPED	.13 (.34)	.15 (.36)	.14 (.35)	-.01 (.01)	.55
Gifted	.11 (.31)	.06 (.24)	.06 (.24)	-.01 (.01)	.47
8th Grade Absence rate	.06 (.06)	.10 (.09)	.11 (.09)	.00 (.00)	.19
8th Grade Math	.06 (.98)	-.25 (.91)	-.26 (.91)	-.02 (.03)	.58
8th Grade Reading	.05 (.97)	-.12 (.97)	-.12 (.98)	-.00 (.03)	.99
Ln(Family Income during 8th Grade)	10.96 (1.15)	10.62 (1.29)	10.61 (1.30)	-.01 (.04)	.72

Note: Each observation is a student who entered 9th grade between 2005-06 and 2008-09. Treatment students attended brick-and-mortar charter schools and comparison students attended traditional public schools. Students in these cohorts that attended brick-and-mortar charters in 8th grade are excluded. Weights are the conditional odds of being in treatment for comparison student and 1 for treatment students, flexibility generated using covariates and dummy indicator for the school attended in 8th grade. Weighted difference and corresponding *p*-values are estimated from regressing (via weighted OLS) the treatment indicator on student characteristics and cohort dummies. Economically Disadvantaged students are eligible for free- reduced priced lunch. Math and Reading Scores are standardized within year and grade to have a mean of 0 and SD of 1 in the population. Income is inflation-adjusted prior to log transformation. Students missing family income data in 8th grade were assigned family income from 7th grade, if available, and the sample mean income otherwise. All estimates have been rounded in accordance with Census rounding rules. N=Observations. ESS= Effective Sample Size. SD= Standard deviation. SE = Standard errors. SPED = students with Special Education status. DRB Approval Number: CBDRB-FY23-CES014-034. Source: ODE, IRS.

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Data Availability Statement

This paper uses confidential microdata that are not available for sharing from the Oregon

Department of Education and the U.S. Census Bureau.