Fiscal and Education Spillovers from Charter School Expansion

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ONLINE APPENDIX

A Temporary Aids Available To School Districts

Five states provide aid to school districts due to students enrolling in charter schools. In addition to Massachusetts, these states include Illinois, New Hampshire, New York, and Pennsylvania.

Illinois

"The State Board of Education shall make the following funds available to school districts and charter schools: (1) From a separate appropriation made to the State Board for purposes of this subdivision (1), the State Board shall make transition impact aid available to school districts that approve a new charter school or that have funds withheld by the State Board to fund a new charter school that is chartered by the Commission. The amount of the aid shall equal 90% of the per capita funding paid to the charter school during the first year of its initial charter term, 65% of the per capita funding paid to the charter school during the second year of its initial term, and 35% of the per capita funding paid to the charter school during the third year of its initial term."

Source: Illinois School Code - Sec. 27A-11.5. State financing.

New Hampshire

"XI. Any money appropriated in the budget for matching chartered public school grants that remains unused after the department of education issues matching grants to eligible recipients under paragraph X shall be used to provide a one-year transitional grant to public school districts that have lost pupils as a result of the establishment of a chartered public school, and have paid tuition to the chartered public school in cash pursuant to subparagraph IX(a). For the first year in which a public school pupil leaves the public school and enrolls in a chartered public school, the school district that loses the pupil shall be eligible for a chartered public school transitional grant beginning July 1, 2004 and every fiscal year thereafter, in an amount per pupil equal to the amount determined in RSA 198:41. Such transitional grants shall be administered by the state board of education which shall have the authority to determine eligibility and the amount of money to be awarded to school districts under this section, subject to the amount appropriated in the budget."

Source: 2017 New Hampshire Revised Statutes. Title XV – EDUCATION. Chapter 194-B - CHARTERED PUBLIC SCHOOLS. Section 194-B:11 - Chartered Public Schools; Funding.

New York

"Transitional Aid for Charter School Payments provides additional State Aid to districts with substantial year to year increases in the proportion of students attending charter schools or the proportion of general fund expenditures that general fund payments to charter schools constitute. Eligible districts can receive Part (a) Transitional Aid and/or Part (b) Transitional Aid and/or Part (c) Transitional Aid.

- Part (a) Transitional Aid = (2017-18 Resident Pupils Enrolled in Charter Schools - 2016-17 Resident Pupils Enrolled in Charter Schools) x 0.80 x 2017-18 Basic Charter School Tuition. A district is eligible for Part (a) Transitional Aid if the number of its resident pupils enrolled in charter schools in 2017-18 exceeded two percent of the 2017-18 total resident public school district enrollment OR the total general fund payments made by such district to charter schools in 2017-18 for resident pupils enrolled in charter schools exceeded two percent of 2017-18 total general fund expenditures.
- Part (b) Transitional Aid = (2016-17 Resident Pupils Enrolled in Charter Schools - 2015-16 Resident Pupils Enrolled in Charter Schools) x 0.60 x 2017-18 Basic Charter School Tuition. A district is eligible for Part (b) Transitional Aid if the number of its resident pupils enrolled in charter schools in 2016-17 exceeded two percent of the 2016-17 total resident public school district enrollment OR the total general fund payments made by such district to charter schools in 2016-17 for resident pupils enrolled in charter schools exceeded two percent of 2016-17 total general fund expenditures.
- Part (c) Transitional Aid = (2015-16 Resident Pupils Enrolled in Charter Schools - 2014-15 Resident Pupils Enrolled in Charter Schools) x 0.40 x 2017-18 Basic Charter School Tuition. A district is eligible for Part (c) Transitional Aid if the number of its resident pupils enrolled in charter schools in 2015-16 exceeded two percent of the 2015-16 total resident public school district enrollment OR the total general fund payments made by such district to charter schools in 2015-16 for resident pupils enrolled in charter schools exceeded two percent of 2015-16 total general fund expenditures."

Section §3602 (41) specifically precludes New York City from receiving this aid.

Source: New York State Education Law §3602(41).

Pennsylvania

"The Commonwealth shall create a grant program to provide temporary transitional funding to a school district due to the budgetary impact relating to any student's first-year attendance at a charter school. The department shall develop criteria which shall include, but not be limited to, the overall fiscal impact on the budget of the school district resulting from students of a school district attending a charter school. The criteria shall be published in the Pennsylvania Bulletin. This subsection shall not apply to a public school converted to a charter school under section 1717-A(b). Grants shall be limited to funds appropriated for this purpose. ((c) amended June 22, 2001, P.L.530, No.35)"

Source: PUBLIC SCHOOL CODE OF 1949 Act of Mar. 10, 1949, P.L. 30, No. 14. ARTICLE XVII-A.CHARTER SCHOOLS.

Table A.1: Timing of District Aid Received by Districts for Charter School Tuition

				Reimbursement							
	Change in	Individual	Current	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	
	charter	tuition	Year	100 pct	25 pct	25 pct	25 pct	25 pct	25 pct	End of	
Year	enrollment	rate	Tuition	reimb	reimb	reimb	reimb	reimb	reimb	reimb	Total Aid
2017	0	9,900	0	0	0	0	0	0	0	0	0
2018	10	10,000	100,000	100,000	0	0	0	0	0	0	100,000
2019	0	0	0	0	25,000	0	0	0	0	0	25,000
2020	0	0	0	0	0	25,000	0	0	0	0	25,000
2021	0	0	0	0	0	0	25,000	0	0	0	25,000
2022	0	0	0	0	0	0	0	25,000	0	0	25,000
2023	0	0	0	0	0	0	0	0	25,000	0	25,000
2024	0	0	0	0	0	0	0	0	0	0	0
Total Aid Disbursed for 2017 change in tuition										0	225,000

† This table presents an example of the timeline for the temporary aid received by districts for Commonwealth charter tuition. In Massachusetts, school districts receive a full refund of the individual tuition the year following the increase in charter school enrollment and a 25% refund for the next five years. In this example, 10 students switch from a traditional public school to a charter school in the year 2017. The district's individual charter tuition equals $US 10,000, so the total charter school tuition payment equals $US 100,000 in 2017. In 2018, the first year after the 10 students have transferred to a charter school, the Chapter 46 aid refunds 100 percent of the total charter school tuition payment, hence $US 100,000. The state then reimburses 25% of the 2017 increase amount for each of the subsequent five years, which amounts to a $US 25,000 refund for each of the years 2019 to 2024. In 2025, the state stops reimbursing the sending district. In the end, the sending district receives $US 225,000 in state refund during the six years following the switch.

B Fiscal Data

B.1 Structure of the Fiscal Data

The table below presents the structure of the Annual Survey of School System Finances collected annually by the Census Bureau. Each cell reports (i) the full name of the variable, (ii) the average value of the variable across all districts in years 2008-2014, (iii) the name of the variable as it appears in the Annual Survey of School System Finances. The items in bold are those we use in our analysis. The items with a grey background are those we consider as fixed costs. SPOB stands for "State Payment on Behalf".

TOTAL ELEMENTARY-SECONDARY REVENUE [47.2k] TOTALREV	Total Revenue from Federal Sources [2.9k] TFEDREV	Compensatory (Title I) [0.6k] C14
		Children with disabilities [0.8k] C15
		Child Nutrition Act [0.5k] C25
		All other federal aid [0.9k] C20
	Total Revenue from State Sources [18.6k] TSTREV	General formula assistance [11.9k] C01
		Transportation programs [0.7k] C12
		All other state revenue [5.9k] C13
	Total Revenue from Local Sources [25.6k] TLOCREV	Parent government contributions [20.2k] T02
		Revenue from cities and counties [3.2k] D23
		Revenue from other school systems [0.4k] D11
		Charges [0.9k] LOCRCHAR
		Other local revenues [0.8k] LOCROTHR

TOTAL ELEMENTARY-SECONDARY EXPENDITURE [46.9k] TOTALEXP	TOTAL CURRENT SPENDING FOR ELEMENTARY-SECONDARY PROGRAMS [42.2k] TCURELSC	**TOTAL CURRENT SPENDING FOR INSTRUCTION [26.8k] TCURINST**	Current operation expenditure - Instruction [24.0k] E13
			State payments on behalf - Instruction benefits [2.8k] J13
		TOTAL CURRENT SPENDING FOR SUPPORT SERVICES [14.1k] TCURSSVC	Pupil support [2.6k] E17
			Instructional staff support [2.2k] E07
			General administration [0.5k] E08
			School administration [1.8k] E09
			Operation and maintenance of plant [3.8k] V40
			Student transportation [1.8k] V45
			Business/central/other support services [1.0k] V90
			SPOB - Pupil support benefits [0.3k] J17
			SPOB - Instructional staff support benefits [0.2k] J07
		TOTAL CURRENT SPENDING FOR OTHER ELEMENTARY-SECONDARY PROGRAMS [1.2k] TCUROTH	Food services [1.1k] E11
			Other elementary-secondary programs [0.06k] V65
	Payments to charter schools [0.9k] V92		
	TOTAL CURRENT SPENDING FOR NONELEMENTARY-SECONDARY PROGRAMS [0.1k] NONELSEC	Community services [0.1k] V70	
		Adult education [0.001k] V75	
		Other nonelem-sec programs [0.001k] V80	
	TOTAL CAPITAL OUTLAY EXPENDITURE [2.7] TCAPOUT	Construction [1.3k] F12	
		Purchase of land and existing structures [1.0k] G15	
		Instructional equipment [0.2k] K09	
		Other equipment [0.1k] K10	
	Interest on school system debt. [0.8k] I86		

B.2 Variables Used for the Fiscal Analysis

ALL OTHER STATE REVENUE:

- Report amounts for specific programs including instructional materials, textbooks, computer equipment, library resources, guidance and psychological services, driver education, energy conservation, **enrollment increases and losses**, health, alcohol and drug abuse, AIDS, child abuse, summer school, prekindergarten and early childhood, adult education (excluding vocational), desegregation, private schools, safety and law enforcement, and community services.

TOTAL CURRENT SPENDING FOR INSTRUCTION:

- "Total current operation expenditure for activities dealing with the interaction of teachers and students in the classroom, home, or hospital as well as co-curricular activities. Report amounts for activities of teachers and instructional aides or assistants engaged in regular instruction, special education, and vocational education programs. Exclude adult education programs."

TOTAL CURRENT SPENDING FOR SUPPORT SERVICES:

- Instruction. "Total current operation expenditure for activities dealing with the interaction of teachers and students in the classroom, home, or hospital as well as co-curricular activities. Report amounts for activities of teachers and instructional aides or assistants engaged in regular instruction, special education, and vocational education programs. Exclude adult education programs."

- Pupil support. "Report expenditures for administrative, guidance, health, and logistical support that enhance instruction. Include attendance, social work, student accounting, counseling, student appraisal, information, record maintenance, and placement services. Also include medical, dental, nursing, psychological, and speech services."

- Instructional staff support. "Include expenditures for supervision of instruction service improvements, curriculum development, instructional staff training, academic assessment, and media, library, and instruction-related technology services."

- General administration. "Expenditure for board of education and executive administration (office of the superintendent) services."

- School administration. "Report expenditure for the office of the principal services."

- Business/central/other support services. "Include business support expenditures for fiscal services (budgeting, receiving and disbursing funds, payroll, internal auditing, and accounting), purchasing, warehousing, supply distribution, printing, publishing, and duplicating services. Also include central support expenditures for planning, research and development, evaluation, information, management services, and expenditures for other support services."

FIXED COSTS:

- We classify as fixed costs the following four items presented in the previous section: General administration, School administration, Operation and Maintenance of Plant, Student Transportation, and Business/central/other support services. Student transportation is classified as a fixed costs because districts have to provide transportation for resident students, regardless of whether they attend district or charter schools.

- We also add the interest on school system debt to the definition, which is defined as follows: "Expenditure for interest incurred on both long-term and short-term indebtedness of the school system. Exclude principal payments."

- We do not include "Capital outlay expenditures" in our definition of fixed costs. This item covers "expenditures for construction of fixed assets; purchasing fixed assets including land and existing buildings and grounds; and equipment. Instructional equipment consists of all equipment (or capital outlay) recorded in general and operating funds under instruction." While these are large expenditures that might be engaged by a district in the current fiscal year, capital outlay expenditures do not correspond to the definition of fixed costs that is interesting in our context, i.e costs that have been engaged by the districts in the past and are difficult to scale down today.

PAYMENTS TO CHARTER SCHOOLS.

- "Indicate in the remarks section whether fall membership counts of students attending charter schools are included in the school system's membership reported in the Common Core of Data Local Education Agency Universe Survey. Also identify in the remarks section the expenditure functions for which the charter school payment was made, if possible. This information will be used in determining per pupil expenditure amounts for the school system."

C Adapting the Synthetic Control Method to Estimate Reduced Form and First Stage

Let's consider the following structural equation in which the charter share C_{jt} is the endogenous variable:

$$Y_{jt} = \gamma_1 + \rho C_{jt} + v_{jt} \tag{1}$$

We want to estimate ρ, the effect of the charter share on our outcome of interest Y_{jt}. We cannot estimate ρ from equation (1) directly by OLS because C_{jt} is potentially correlated with district-specific unobservables v_{jt}. Therefore, we instrument C_{jt} with a dummy for expanding districts, E_j, that takes the value one for expanding districts and zero for the synthetic control districts. A dummy for expansion would clearly be endogenous when expanding districts are compared to all other districts. Comparing expanding districts to their synthetic control provides a more plausibly exogenous instrument. The first stage and reduced-form equations are:

$$C_{jt} = \gamma_2 + \beta E_j + u_{jt} \tag{2}$$
$$Y_{jt} = \gamma_1 + \alpha E_j + \xi_{jt} \tag{3}$$

where $\alpha = \beta\rho$. We use the following synthetic control procedure to estimate separately the reduced form treatment effect, α, and the first stage coefficient, β. Consider a sample of $J+1$ districts indexed by j, and assume that district $j = 1$ will be the treated district (that is, the expanding district), while districts $j = 2$ to $j = J+1$ are potential control districts. The sample includes T_0 pre-reform years as well as T_1 post-reform years, with $T = T_0 + T_1$.

$Y_{jt}(1)$ and $Y_{jt}(0)$ are the potential outcomes with and without treatment. The treatment effect for district j at time T_0 can be defined as:

$$\alpha_{jt} = Y_{jt}(1) - Y_{jt}(0) = Y_{jt} - Y_{jt}(0) \tag{4}$$

We are interested in estimating the vector $(\alpha_{j,T_0+1}, ..., \alpha_{j,T})$. This is the reduced form estimate of the IV-SC method. Abadie et al. (2010) show that we can identify the above treatment effects under the following model for the potential outcomes:

$$Y_{jt}(0) = \delta_t + Z_j\theta_t + \lambda_t\mu_j + \epsilon_{jt} \tag{5}$$
$$Y_{jt}(1) = \delta_t + Z_j\theta_t + \lambda_t\mu_j + \alpha_{jt} + \epsilon_{jt} \tag{6}$$

Potential outcomes depend on a common factor δ_t, a vector of observed covariates Z_j that are not affected by the intervention, a vector of time-specific parameters θ_t, a district-specific unobservable μ_j, and an unknown common factor λ_t. ϵ_{jt} is a transitory shock with zero mean. Finally, α_{jt} is a reduced-form year-specific treatment effect that is different from 0 only when $j = 1$ and $t > T_0$. The model allows the impact of unobservable district heterogeneity to vary with time, unlike standard differences-in-differences or fixed-effect specifications that assume λ_t is constant over time. We can identify the first stage effect under the following model:

$$C_{jt} = \eta_t + Z_j\phi_t + \kappa_t\nu_j + \beta_{jt} + \xi_{jt} \tag{7}$$

The terms have the same interpretation as for the potential outcome. β_{jt} is a first-stage year-specific treatment effect that is different from 0 only when $j = 1$ and $t > T_0$.

Define a $(J \times 1)$ vector of weights $W = (w_2, ..., w_{J+1})$ such that $w_j \geq 0$ and $\sum w_j = 1$. Each possible choice of W corresponds to a potential synthetic control for the treated district. The value of the outcome variable for each synthetic control (indexed by W) is:

$$\sum_{j=2}^{J+1} w_j Y_{jt} = \delta_t + \theta_t \sum_{j=2}^{J+1} w_j Z_j + \lambda_t \sum_{j=2}^{J+1} w_j \mu_j + \sum_{j=2}^{J+1} w_j \epsilon_{jt} \tag{8}$$

The value of the endogenous variable for each synthetic control is:

$$\sum_{j=2}^{J+1} w_j C_{jt} = \eta_t + \phi_t \sum_{j=2}^{J+1} w_j Z_j + \kappa_t \sum_{j=2}^{J+1} w_j \nu_j + \sum_{j=2}^{J+1} w_j \xi_{jt} \tag{9}$$

Finally, assume a vector of weights $(w_2^*, ..., w_{J+1}^*)$ that makes it possible to equalize three equations for each pre-reform year. First, the vector of weights equalizes the values of the pre-reform outcomes for the treated districts and the synthetic control. In addition, the vector of weights equalizes the values of the observed covariates Z_j of the reduced form equation for the treated districts and the synthetic control. Formally, for each period t:

$$\sum_{j=2}^{J+1} w_j^* Y_{jt} = Y_{1t} \quad \text{and} \quad \sum_{j=2}^{J+1} w_j^* Z_{jt} = Z_{1t} \tag{10}$$

Importantly, the vector of weights also equalizes the values of the pre-reform endogenous variable for the treated districts and the synthetic control:

$$\sum_{j=2}^{J+1} w_j^* C_{jt} = C_{1t} \tag{11}$$

If the vector of weights $(w_2^*, ..., w_{J+1}^*)$ exists, Abadie et al. (2010) show that the reduced form treatment effect α_{jt} can be estimated by:

$$\hat{\alpha_{jt}} = Y_{1t} - \sum_{j=2}^{J+1} w_j^* Y_{jt} \tag{12}$$

Using the same proof, we show that the first stage coefficient can be estimated by:

$$\hat{\beta_{jt}} = C_{1t} - \sum_{j=2}^{J+1} w_j^* C_{jt} \tag{13}$$

Considering a single treated unit and the effect of an intervention averaged over all post-intervention years allows us to omit the j and t subscripts. The instrumental-variable synthetic control (IV-SC) estimator of the parameter ρ in the structural equation 1 is the ratio of the reduced form estimate $\hat{\alpha}$ to the first stage $\hat{\beta}$:[55]

$$\rho_{IV-SC} = \frac{\hat{\alpha}}{\hat{\beta}} \tag{14}$$

In practice, this IV-SC estimator can be obtained either by estimating the first stage and the reduced form separately, and then taking the ratio of the two, or by running a weighted two-stage least squares (2SLS) regression of the post-intervention outcome variable on the post-intervention instrumented endogenous variable. In this regression, each control unit is weighted based on the synthetic control weights, while the treated unit has a weight of one. When several units are treated, a synthetic control can be computed for each treated unit separately or for the group of treated units as a whole. We chose the latter option in our application.

It should be noted that the synthetic control reduced-form estimate $\hat{\alpha_{jt}}$ is unbiased whereas the IV-SC estimator suffers from the standard bias of the 2SLS estimator (although it is consistent). This bias, however, might be limited. The 2SLS bias is an increasing function of the number of instruments. By definition, when only one unit is treated, the IV-SC estimator relies on a single instrument (a dummy for treated and synthetic control districts), and the just-identified 2SLS estimator is median-unbiased.

Finally, note that although we call our method "IV-SC", it differs in important ways from methods that use instrumental variables to eliminate bias due to selection into treatment. We instead use the synthetic control method to estimate an unbiased reduced-form treatment effect, and we then scale this effect by the first stage, which we estimate using the same group of

[55]Note that this IV-SC estimator could also be interpreted as simply providing an appropriate scaling for the reduced-form treatment effect of expansion, α.

weighted control districts. We think, however, that the IV-SC terminology illustrates well the novel attempt to use a dummy variable for treated versus synthetic control as an instrumental variable.

Modified Synthetic Control In Practice

In practice, let X_1 be the vector of pre-reform characteristics for the expanding districts and X_0 the matrix of the vectors of the non-expanding districts' pre-reform characteristics. Districts weights w^* are then chosen to minimize the distance $\|X_1 - X_0 w\| V = \sqrt{(X_1 - X_0 w)' V (X_1 - X_0 w)}$ where V is a $(k \times k)$ symmetric and positive semidefinite matrix that represents the weight of each predictor variable. A novelty with the IV-SC is that X_1 and X_0 should include the endogenous variable. X_0 and X_1 are predictors of the outcome variable, the most important of which is usually the lagged outcome variable because it accounts for the effects of any potentially unobserved predictor variables in pre-reform years. Indeed, only units that are sufficiently similar in both observed and unobserved outcome variable determinants as well as in those determinants' effects on the outcome variable should produce similar outcome trajectories over extended periods of time.

D Criteria Used to Evaluate Charter Schools Applications

The Massachusetts Department for Elementary and Secondary Education (DESE) uses 93 criteria to evaluate applications submitted to open a new charter school. This Appendix presents the criteria that we classified as potentially related to the fiscal or education outcomes we look at. For a matter of space, we do not report the full list of criteria in this Appendix, but the list can be accessed in an annual DESE's publication titled "Review Process for Charter Applications and Criteria for Review". We classified the following six criteria as potentially related to districts' fiscal or education outcomes. For each criteria, we justify why we considered it might be related to districts' fiscal or education outcomes.

1. "The application describes how this school will enhance or expand the educational options available to the targeted student population, including whether the innovative methods to be used by the proposed school differ from the district or districts from which the charter school is expected to enroll students."

   Justification: A charter school application might be more likely to be accepted in districts where the arrival of a charter school enhances or expands more the educational options available to the targeted student population, for instance in districts that do not currently have a charter school.

2. "State law asserts that charter schools are to be established to 1) stimulate the development of innovative programs within public education; 2) provide opportunities for innovative learning and assessments; 3) provide parents and students with greater options in choosing schools within and outside of their school districts"

   Justification: A charter school application might be more likely to be accepted in districts where school choice is more limited, and school choice might be a determinant of education outcomes.

3. “The application discusses the reason for the selection of the community(ies) and the applicant’s ability to serve this particular area and current connections to the community.”

   Justification: A charter school application might be more likely to be accepted in districts where the community(ies) served by the school are more disadvantaged, which is a determinant of students’ achievement.

4. “The application describes supporting evidence for the projected student enrollment at the proposed Commonwealth charter school, such as an analysis of eligible potential students in the community(ies) to be served, analysis of documented demand from families with eligible potential students, and/or an analysis of enrollment at schools currently operating in the community(ies) to be served. Applicants should not submit copies of petitions or interest forms in the charter application.”

   Justification: A charter school application might be more likely to be accepted in districts where the projected student enrollment is large, especially among low performing students, or in districts in which parental support is large. Both could be a determinant of educational achievement.

5. “The application demonstrates that the proposed educational program will serve the diverse needs of individual students by providing evidence, including explicit research citations, that demonstrates their educational program and its associated educational practices may result in high academic achievement and the attainment of the knowledge, skills, and experiences that ensures college and career readiness for the anticipated student population. Evidence should include the specific subgroups of students listed in the recruitment and retention plan consistent with requirements of M.G.L. c. 71, § 89, such as students with disabilities, English learners, and students participating in the federal free/reduced lunch nutrition program.”

   Justification: A charter school application might be more likely to be accepted if the submitted educational program has been identified as more effective for under-performing students and the district has a larger share of underperforming students.

6. “The application summarizes financial forecasts from the school’s start-up phase through its fifth year of operation. Financial forecasts must include total expected realistic sources of revenue—including tuition and other grants (federal, state, and private), and fundraising—as well as all expenditures, the timeframe for a positive cash balance, and the anticipated growth of the school. Define and give support for the assumptions behind projections.”

   Justification: A charter school application might be more likely to be accepted in districts where per-pupil revenue and charter tuitions are higher.

Between 2011 and 2015, the Massachusetts Department for Elementary and Secondary Education received 49 applications for new charter schools, and rejected 19 of them. For each application, we collected information on the sending districts and on the strengths and weaknesses of the application as they are reported in the States meeting minutes. We use the list of weaknesses to determine if some were refereeing to one of the six criteria identified above. When one of the application weaknesses refers to a criteria identified above as potentially related to a district’s financial or education outcome, we code the entire application as rejected for a reason related to potential outcomes, and we omit the associated sending district(s) from the synthetic control donor pool.

The following table presents, for each of the 19 rejected applications, what would have been their sending districts, whether we classified the rejection as related to a potential fiscal or education outcome, and the criterion that justifies this classification.

Table A.2: Rejected Charter School Applications

Charter school name	Sending districts	Opening Year	Rejection Criteria
Paulo Freire Social Justice Charter School	Agawam, Amherst, Amherst-Pelham, Belchertown, Brimfield, Chesterfield-Goshen, Chicopee, E. Longmeadow, Easthampton, Gateway Regional, Granby, Granville, Hadley, Hampden-Wilbraham, Hampshire Regional, Hatfield, Holland, Holyoke, Longmeadow, Ludlow, Monson, Northampton, Palmer, Pelham, S. Hadley, Southampton, Southwick-Tolland, Springfield, Wales, Ware, W. Springfield, Westfield, Westhampton and Williamsburg	2011-12	
Boston Chinese Immersion Charter School	Boston	2011-12	
Dudley Square Preparatory Charter School	Boston	2012-13	
Lynn Preparatory Charter School	Lynn	2011-12	
Collegiate Charter School	Springfield, West Springfield, Chicopee	2011-12	
Springfield Preparatory Charter School	Springfield	2012-13	
Somerville Progressive Charter School	Somerville	2012-13	
YouthBuild Academy Charter School	Lawrence	2013-14	
Brooke Charter School 4	Boston	2013-14	
Argosy Collegiate Charter School	Fall River	2014-15	
Brooke 4 Charter School	Boston	2014-15	
International Charter School of Brockton	Brockton	2014-15	4
Pioneer Charter School of Science IV	Woburn, Stoneham, Medford, Melrose, Wakefield, Saugus	2014-15	
Springfield Collegiate Charter School	Springfield	2014-15	
Academy for the Whole Child Charter School	Fitchburg	2014-15	
Fenix Charter School	Lynn	2014-15	
STEAM STUDIO	Andover	2014-15	4
New Heights Charter School of Fall River	Fall River	2015-16	4
Academy for the Whole Child Charter School	Fitchburg, Leominster, Lunenburg, Ashburnham-Westminster, North Middlesex, Athol-Royalston, Gardner, Orange, Winchendon	2015-16	
New Heights Charter School of Brockton	Brockton	2015-16	

† Notes: This table lists all rejected charter school applications in Massachusetts between 2011-2012 and 2015-2016. Column (2) reports what would have been the sending district(s), column (3) what would have been the opening year, and column (4) the criterion—if any—that justifies why we classified the rejection as related to a potential fiscal or education outcome.

Table A.3: Synthetic Control Districts' Weights - Per-pupil revenue

	Charter Payments	State refund	Fed rev	State rev	State exc refund	Local rev	Total rev
Cambridge	0.257	0.035		0.024		0.085	0.119
Chicopee			0.029	0.042	0.01	0.004	0.056
Clinton					0.076		
Fitchburg	0.044		0.251	0.199	0.310	0.466	0.617
Greenfield		0.235					
Leominster			0.112	0.033	0.033		
Methuen		0.004	0.056	0.144	0.058		
Nantucket						0.019	
Oxford	0.006			0.01	0.039		
Revere	0.263		0.077	0.016	0.091	0.066	
Somerville		0.132				0.242	
Springfield		0.024	0.342	0.269	0.332	0.118	0.137
Ware			0.103				
Wareham		0.123					
Worcester	0.388	0.447	0.031	0.121			
Athol-Royalston				0.089			
Gateway	0.041						
Ralph C Mahar				0.056	0.051		0.07

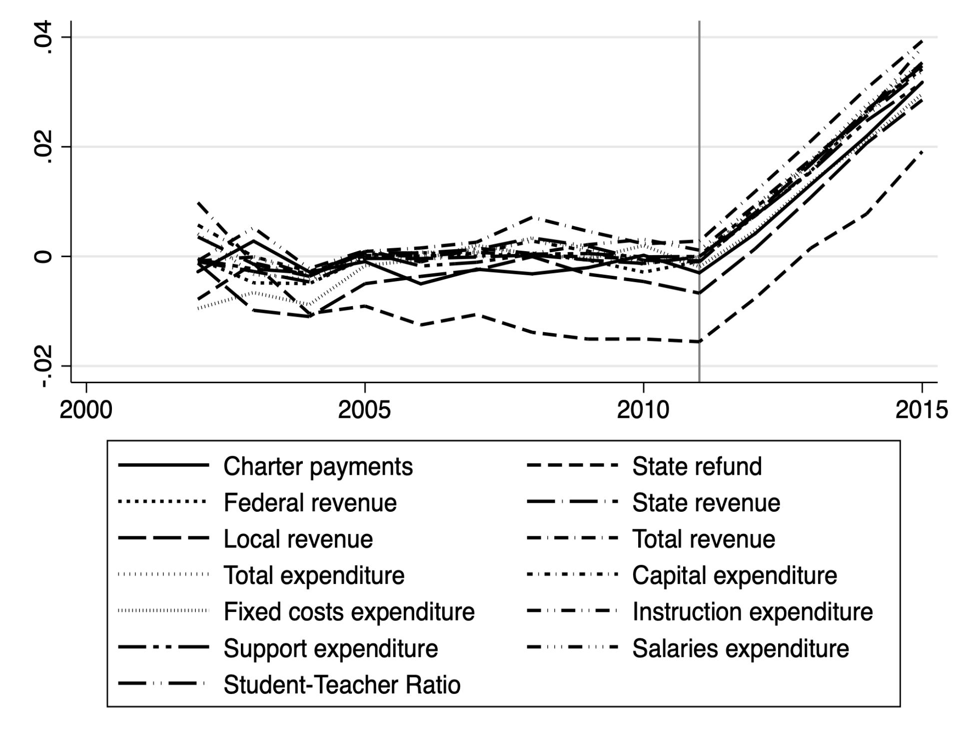
† Notes: This table reports the district weights assigned by the synthetic control method. "State refund" refers to the category "other state revenue" in our data which includes the refund for payments to charter schools. "State exc refund" refers to the state revenue minus this category. "Net rev" refers to total revenue minus payments to charter schools.

Table A.4: Synthetic Control Districts' Weights - Per-pupil expenditures & Test Scores

	Per-pupil expenditures						Student-	Test scores	
	Total exp	Fixed costs	Capital outlay	Instru-ction	Salaries	Support services	Teacher Ratio	Math	English
Cambridge	0.082		0.104	0.085	0.044	0.216	0.067	0.096	
Chicopee	0.063			0.242			0.159		
Clinton			0.01		0.051				
Easthampton							0.06		
Fitchburg	0.427		0.398	0.215	0.181	0.184	0.37		
Gardner								0.261	
Greenfield			0.087	0.029					0.042
Lee									0.139
Leominster									
Methuen	0.031		0.123			0.265			
Monson								0.040	
Nantucket	0.024				0.072				
Orange								0.037	
Oxford			0.006	0.007					
Revere	0.074				0.169	0.032	0.056		
Rockland									0.031
Somerville		0.391						0.124	
Springfield	0.252	0.001	0.175	0.073	0.174	0.234	0.185	0.033	0.265
Waltham									0.094
Ware	0.028	0.111		0.023	0.075				
Wareham		0.153	0.033	0.014					
Westfield									0.112
Winthrop		0.124							
Worcester		0.219	0.058	0.312	0.234	0.069	0.102	0.306	0.200
Athol-Royalston				0.001					0.028
Mohawk Trail								0.104	0.049
Pioneer Valley			0.005						0.041
Ralph C Mahar	0.02		0.001						

† Notes: This table reports the district weights assigned by the synthetic control method for the following outcomes: Per-pupil spending, student-teacher ratio, and test scores.

Figure A.1: Summary of First Stage Effects Across Outcomes



Notes: This Figure plots, for each outcome, the difference between the charter share in expanding districts and the charter share in the synthetic control group.

Table A.5: 2SLS Estimates of Fiscal Spillovers - Results Unweighted with the Synthetic Control Weights

	Per-pupil revenue						Per-pupil expenditures on:						Student-
	Charter Payments (log) (1)	Temp Refund (log) (2)	Fed Rev (log) (3)	State Net Rev (log) (4)	Local Rev (log) (5)	Total Net Rev (log) (6)	Total exp (log) (7)	Capi-tal (8)	Fixed costs (log) (9)	Instru-ction (log) (10)	Salaries (log) (11)	Support (log) (12)	Teacher Ratio (13)
Charter share	14.83***	21.51**	1.61	-2.59*	0.83	0.67	1.72*	14.79	0.93	1.36**	1.42***	-0.80	-10.30
	(5.18)	(9.01)	(2.19)	(1.41)	(1.49)	(1.03)	(0.96)	(15.45)	(0.87)	(0.53)	(0.44)	(0.81)	(7.52)
N	209	220	238	252	224	196	238	280	210	238	238	210	165
R2	0.791	0.508	0.741	0.618	0.900	0.795	0.793	0.155	0.772	0.923	0.941	0.905	0.822
First stage F-Stat	29.4	18.7	32.8	37.4	24.3	22.7	28.9	32.0	23.1	28.1	27.6	23.4	28.5
Mean Y (in $)	598.2	144.6	1964.2	10002.5	6452.3	17965.4	17491.6	1378.1	3489.9	9848.5	8650.8	3421.4	
Scaled effect (in %)	74.2	107.5	8.0	-12.9	4.1	3.4	8.6	53.7	4.6	6.8	7.1	-4.0	
Scaled effect (in $)	443.6	155.5	158.0	-1293.4	266.5	603.1	1505.2	739.7	161.5	670.2	614.2	-137.6	-

† Notes: This table reports 2SLS estimates of charter expansion's effect on districts' per-pupil revenues and expenditures. For all outcomes, we use the log of the variable, except for the spending on capital, and student-teacher ratio. "State Net Rev" refers to the state revenue minus this the temporary refund. "Toal Net rev" refers to total revenue minus payments to charter schools. The endogenous variable is the charter share, which is a continuous variable that ranges from 0 to 1. We use three instruments: the interaction between a post-reform years dummy and a dummy for (i) Boston, (ii) other urban expanding districts, and (iii) nonurban expanding districts. All regressions control for districts fixed effects, and post-reform years. For standard errors, we use the White estimator of variance. Mean Y (in $) shows the mean value of the outcome (expressed in dollars) in expanding districts in 2010 (the last pre-reform year). Scaled effect (%) reports the scaled effect, i.e., the change in outcome (expressed in percent) if charter share goes up by five percentage points. This corresponds to the coefficient reported in the top row divided by twenty (and multiplied by 100 to read the statistic directly as a percentage). Scaled effect ($) shows the change in outcome (expressed in dollars) if charter share goes up by five percentage points. This statistic corresponds to the mean value of the outcome multiplied by the row "Scaled effect (%)" and divided by 100 to read the statistic directly as a percentage change in dollars. ***, **, and *: Significant at the 1, 5, and 10 percent level.

Table A.6: First Stage Estimates of Fiscal Spillovers

		Per-pupil revenue					Per-pupil expenditures on:						Student-
	Charter	Temp	Fed	State	Local	Total	Total	Capi-	Fixed	Instru-			Teacher
	Payments	Refund	Rev	Net Rev	Rev	Net Rev	exp	tal	costs	ction	Salaries	Support	Ratio
	(log)	(log)	(log)	(log)	(log)	(log)	(log)		(log)	(log)	(log)	(log)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Post-Reform * Boston	0.0503***	0.0470***	0.0530***	0.0527***	0.0508***	0.0537***	0.0529***	0.0518***	0.0504***	0.0524***	0.0523***	0.0512***	0.0493***
	(0.0088)	(0.0086)	(0.0089)	(0.0089)	(0.0089)	(0.0090)	(0.0088)	(0.0087)	(0.0091)	(0.0090)	(0.0088)	(0.0088)	(0.0089)
Post-Reform * Other urban	0.0164***	0.0130***	0.0191***	0.0188***	0.0169***	0.0197***	0.0190***	0.0179***	0.0165***	0.0185***	0.0183***	0.0173***	0.0181***
	(0.0032)	(0.0033)	(0.0031)	(0.0031)	(0.0032)	(0.0034)	(0.0030)	(0.0030)	(0.0031)	(0.0035)	(0.0029)	(0.0030)	(0.0027)
Post-Reform * Nonurban	0.0154***	0.0110**	0.0175***	0.0173***	0.0153***	0.0182***	0.0174***	0.0163***	0.0149***	0.0169***	0.0168***	0.0157***	0.0204***
	(0.0044)	(0.0043)	(0.0044)	(0.0044)	(0.0045)	(0.0046)	(0.0043)	(0.0043)	(0.0045)	(0.0047)	(0.0043)	(0.0043)	(0.0036)
N	209	220	238	280	224	196	252	280	252	266	238	210	165
First stage F-Stat	17.5	12.8	22.2	21.8	17.6	20.0	21.7	21.5	17.8	17.5	23.9	21.1	26.9

† Notes: This table reports first stage estimates of charter expansion effects on districts' per-pupil revenue and expenditures. The dependent variable is the charter share, which is a continuous variable that ranges from 0 to 1. In this over-identified model, we use three instruments: (i) the interaction between a post-reform years dummy and a Boston dummy, (ii) the interaction between a post-reform years dummy and a dummy for other urban expanding districts, and (iii) the interaction between a post-reform years dummy and a dummy for nonurban expanding districts. All regressions control for expanding districts and post-reform years. For standard errors, we use the White estimator of variance. Because we use the synthetic control districts as a control group, the first stage coefficients and the number of observations vary depending on how many synthetic control districts were identified for each outcome.

*** Significant at the 1 percent level.

** Significant at the 5 percent level.

* Significant at the 10 percent level.

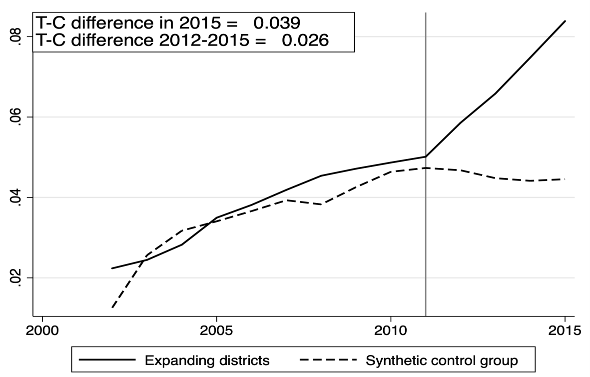
Table A.7: 2SLS Estimates of Charter School Expansion's Impact on Achievement – Unweighted with Synthetic Control Weights

	Math		ELA	
	First Stage	2SLS	First Stage	2SLS
	(1)	(2)	(3)	(4)
Charter share		2.22**		1.30
		(1.03)		(0.82)
Post-reform * Boston	0.0412***		0.0447***	
	(0.0098)		(0.0098)	
Post-reform * Other urban	0.0136***		0.0171***	
	(0.0035)		(0.0035)	
Post-reform * Non urban	0.0114**		0.0150***	
	(0.0049)		(0.0049)	
N	204	204	228	228
R2		0.703		0.746
First-Stage F-Stat	10.7		14.8	

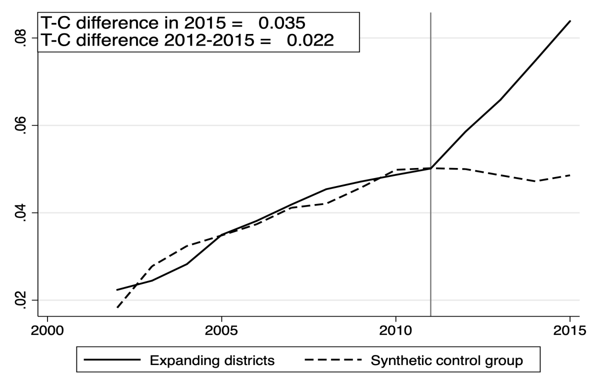
† Notes: This table reports first stage and 2SLS estimates of charter expansion's effect on student achievement. To control for student selection into charter schools, the outcome variable is the district-time fixed effects from a regression of students' test scores on a set of students' demographic characteristics and a dummy for individual charter enrollment (instrumented by receiving a charter lottery offer). We then use a district-time level 2SLS regression to estimate the effect on this outcome of the charter share, which is a continuous variable that ranges from 0 to 1. The sample for each regression includes only the expanding districts and the synthetic control group districts, i.e. districts given a positive weight for that outcome in our synthetic control, but we do not use the synthetic control weights themselves. We use three instruments for charter share: (i) the interaction between a post-reform years dummy and a Boston dummy, (ii) the interaction between a post-reform years dummy and a dummy for other urban expanding districts, and (iii) the interaction between a post-reform years dummy and a dummy for nonurban expanding districts. Columns 1 and 3 show the first-stage effects of these instruments on the charter share and Columns 2 and 4 show the effect of the charter share on residualized test scores as estimated by 2SLS. All regressions control for district fixed effects, and post-reform years. For standard errors, we use the White estimator of variance. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Figure A.2: Charter Share in the Synthetic Control Group for each Per-Pupil Expenditure Variable

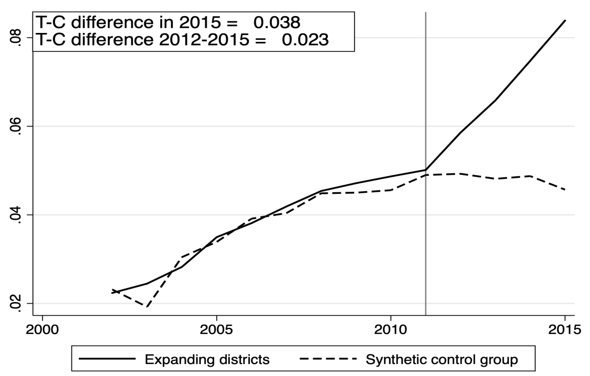
(a) Total revenue



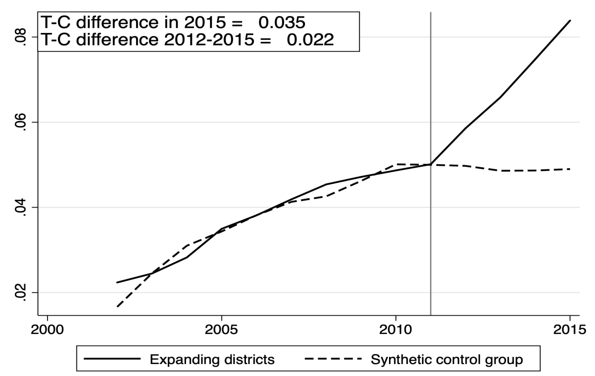
(b) Total spending



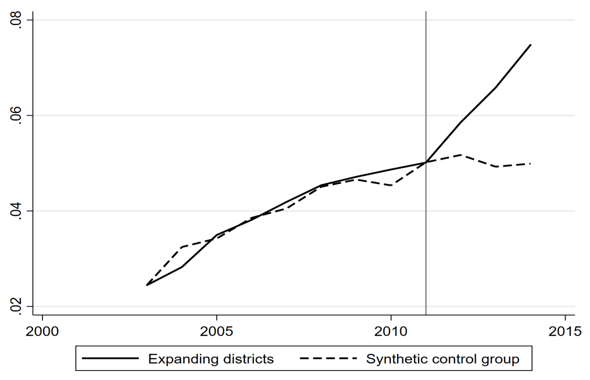
(c) Spending on instruction



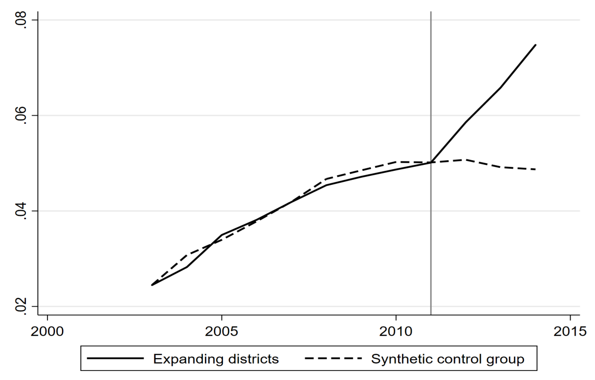
(d) Spending on support services



(e) Math score



(f) ELA score



Notes: This figure plots the share of students attending a charter school in the synthetic control group for each financial outcome variable, as a test of the 'fuzzy-DiD' assumption that the treated share in the control group remains constant. The graphs differ from one another only because different weights are used to construct the synthetic control for each outcome variable. The charter share in the treatment group is provided for comparison.

Table A.8: Massachusetts Charter Schools Eligible for the Lottery Instrument, and Grades of Lottery

Charter School Name	Town	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Academy Of the Pacific Rim	Boston			6	6	5-6	5	5	5	5	5	5	
Boston Collegiate	Boston					5	5	5	5	5	5	5	5
Boston Preparatory	Boston						6	6	6	6	6	6	6
Brooke - Roslindale	Boston					5	5	5					
Codman Academy	Boston												5
Excel Academy - East Boston	Boston						5	5	5	5	5	5	
MATCH Community Day	Boston						6	6	6	6	6	6	6
Roxbury Preparatory	Boston				6	6	6	6	6	6	5	5	5
Brooke - East Boston	Boston										5	5	5
Brooke - Mattapan	Boston									5	5	5	5
Excel Academy - Orient Height	Boston										5	5	
Grove Hall 2011 (UCS)	Boston									5			
KIPP Academy Boston	Boston										5	5	5
Cape Cod Lighthouse	Orleans					6	6	6	6				
Four Rivers	Greenfield	7	7	7	7	7	7	7	7				
Francis W. Parker	Devins				7	7	7	7	7				
Global Learning	New Bedford				5	5		5					
Kipp Academy Lynn	Lynn			5	5	5	5	5					
Murdoch Middle - Innovation	Tyngsboro					5	5	5	5				
Pioneer Valley Performing Arts	South Hadley				7	7	7	7	7				
Rising Tide	Plymouth							5					
Salem Academy	Salem								6				

† Notes: This table lists all charter schools in Massachusetts eligible for the lottery instrument in middle school. The number in each cell indicates the grade of lottery.

Table A.9: Lottery Estimates of Charter Effects

	First stage			2SLS
	(1)	(2)	(3)	(4)
		Math		
Charter	0.455***			-0.331**
	(0.0608)			(0.117)
Charter*Urban		0.312***		0.932***
		(0.0232)		(0.126)
Charter*Post Reform			0.497***	0.0830**
			(0.0263)	(0.0320)
N	2985484	2985484	2985484	2985484
F stat	400.53	398.88	318.77	
		ELA		
Charter	0.456***			-0.160
	(0.0616)			(0.0978)
Charter*Urban		0.312***		0.398***
		(0.0230)		(0.106)
Charter*Post Reform			0.495***	0.186***
			(0.0267)	(0.0262)
N	2752583	2752583	2752583	2752583
F stat	420.89	415.74	331.89	

† Notes: This table reports first stage and 2SLS estimates of charter school attendance's effects on student achievement. Columns 1, 2, and 3 show estimates of the first stage coefficients, and column 4 shows estimates of the 2SLS coefficients. There are three endogenous variables: a dummy for charter school attendance, the interaction between charter attendance and a dummy for urban schools, and the interaction between charter attendance and a dummy for post-reform years. We use three sets of instruments: a lottery offer dummy, a lottery offer for an urban charter dummy, and a lottery offer for a charter school after the reform dummy. Each endogenous variable is instrumented by the three instruments. However, for readability, we only report the coefficient of the relevant instrument in the first three columns, that is (1) the coefficient on the lottery offer dummy for the charter school attendance variable, (2) the coefficient on the urban charter lottery offer for the interaction between charter attendance and urban schools, and (3) the coefficient on the post-reform lottery offer for the interaction between charter attendance and post-reform years. All regressions control for race, sex, special education, limited English proficiency, subsidized lunch status, and a female by minority dummy. District-by-year dummies and risk set dummies are also included. Estimates pool post-lottery outcomes for grades 4-8 and cluster by student identifier as well as district.

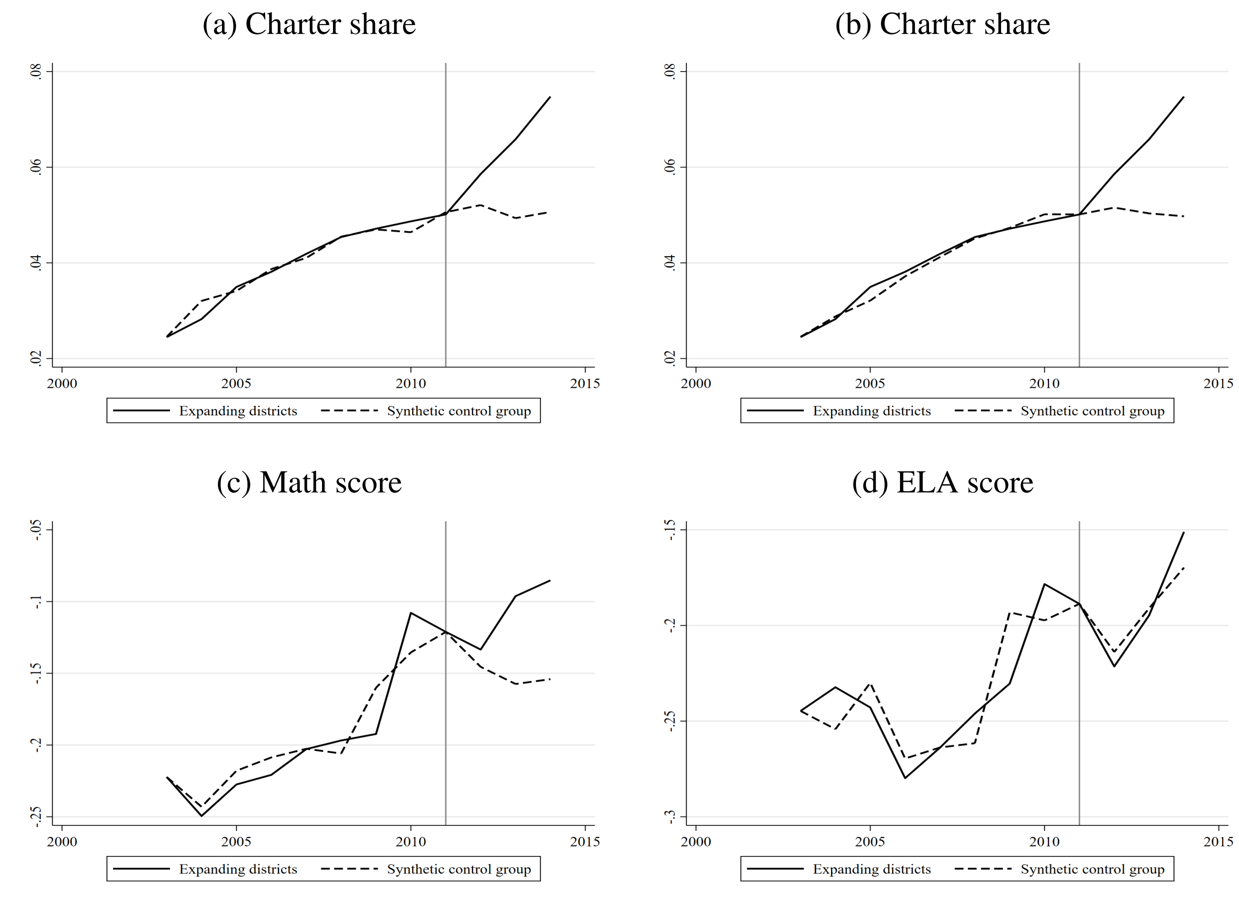
*** Significant at the 1 percent level.

** Significant at the 5 percent level.

* Significant at the 10 percent level.

Figure A.3: Charter Share and Students' Achievement in alternative specification with increased heterogeneity of direct charter effect

Mathematics ELA



Notes: This figure plots the share of students attending a charter school (plots a and b) and students' average math and ELA test scores (plots c and d). The plain lines represent districts that saw an increased share of students attending a charter school after the 2011 reform (expanding districts), and the dotted lines represent the synthetic control districts. The test scores used for this figure are the residuals of a regression of students' raw test scores on a set of students' demographic characteristics and a dummy for individual charter enrollment. This regression interacts individual charter enrollment with indicators for being in Boston, being in a non-Boston expanding district, being post the 2011 reform, being in Boston post-reform, and being in a non-Boston expanding district post-reform. Charter enrollment interacted with each indicator is instrumented by receiving a lottery offer interacted with each indicator.

E Sensitivity Tests for the Synthetic Control Specifications

Sensitivity tests for predictor variable weights

We test two options for the method used to compute the predictor variable weights: a standard method and a cross-validation method.

The standard method is an iterative optimization procedure that searches among all predictor weights matrices and sets of districts weights for the best-fitting convex combination of the control units. Best-fitting refers to the fit between the pre-reform outcomes of the treated districts and synthetic control. More specifically, the optimization problem uses four inputs: X_1, the vector of pre-reform characteristics for the treated district (that is, the expanding districts), X_0 the matrix of the vectors of the untreated districts' pre-reform characteristics, Y_1 the vector of pre-reform outcomes for the treated district, and Y_0 the matrix of the vectors of the untreated districts' pre-reform outcomes.

In the standard optimization method, the optimization proceeds in three steps:

1. For given predictor weights $V = (v_1, ..., v_k)$, the donor weights $w^*(V)$ are chosen to minimize the distance $\|X_1 - X_0 w\|V = \sqrt{(X_1 - X_0 w)' V (X_1 - X_0 w)}$ so that $w^*(V) > 0$ and the donor weights sum up to one.

2. Given the donor weights $w^*(V)$, optimal predictor weights V^* are chosen to minimize $\|Y_1 - Y_0 w^*(V)\|^2$ so that $V^* > 0$ and the predictor weights sum up to one.

3. The final donor weights are computed as $w^*(V^*)$.

The cross-validation method consists of dividing the pre-intervention period into two subperiods: a training period and a validation period. The optimization follows the three steps presented above, with two exceptions: in step 1, the minimization only applies to the *training period*, while in step 2, the minimization only applies to the *validation period*.

The results in Tables A.12 and A.13 show that using the cross-validation method often produces lower-quality fit for outcome variables than the standard optimization method. This is the reason why we only use the cross-validation method when we considered that the cost in terms of fit quality was not too large. This is the case for the per-pupil expenditures and per-pupil expenditures on instruction. Results for the other outcomes rely on the standard optimization method.

Sensitivity tests for predictor variables

For most results presented in the paper, we use four years of lagged outcome variables as predictor variables and four years of charter share (with the exception of results on total spending and spending on instruction that use cross-validation). Including lagged outcome variables and lagged charter share is crucial to ensuring that these variables' pre-reform trends are as similar as possible in expanding districts and the synthetic control. However, including too many lagged outcome variables might render other outcome predictors irrelevant (Kaul et al., 2017). We check if the number of lagged values impacts the fit quality for both the outcome variable (for the reduced form estimates) and the charter share (for the first stage estimates).

Specifications 2 and 5 in Tables A.12 and A.13 compare results for specifications using 4 lags (for years 2003, 2006, 2008, and 2011) versus all lags (9 years). The sensitivity tests reveal that including all lags tends to either yield similar results (for spending on instruction and fixed costs) or raises overfitting concerns. Using all lags increases the chance that donor districts are matched because of idiosyncratic noise rather than an underlying trend shared with the expanding districts. Overfitting occurs when expanding districts are matched to a large number of donor districts, many of which have very small weights. For total spending and spending on support services and salaries, for instance, the number of synthetic controls jumps from 4, 6, and 8 to respectively 31, 32, and 32 when we use all lags instead of four.

Sensitivity tests for achievement outcomes

For the achievement outcomes, some more explanation is due for why we chose the specification we did (which differs from that for fiscal outcomes). Figure 6 shows that test scores vary more over time than the fiscal outcomes. This has two consequences when using the SC method. First, it is more difficult to obtain a good fit on test scores than on fiscal outcomes (as shown in Figures 4 and 6). When choosing a specification, we therefore paid particular attention to the fit quality on test scores. Second, the larger variability of test scores increases the risk of overfitting when we chose the SC. Table A.13 confirms that several specifications give 10 or more districts in the SC, which we use as an informal overfitting threshold.[56] In order to mitigate the overfitting and poor fit quality risks, we use the following rule to identify our preferred specification: First, we start by omitting the specifications that overfit. Then, we select the specification that minimizes the RMSPE on test scores. For consistency, we also try to use the same specification in math and ELA. That rule leads us to use a specification without cross-validation, with 4 lagged values of test scores and charter share (and additional predictor variables), and a donor pool that contains districts whose student achievement is in the bottom 25th percentile of the achievement distribution.

F Alternative estimation approaches for achievement outcomes

Our estimation approach for achievement outcomes described in section 6 may be biased if it does not fully capture the heterogeneity in the direct effect of charter attendance $\tilde{\beta}_{idt}$. In particular, we lack statistical power to fully allow for a different direct effect of charter schools in every district-by-time cell, and our use of the lottery instrument means that we cannot identify a heterogeneous effect of charter schools which did not run lotteries.

We use two robustness checks to confirm that these potential sources of bias are unlikely to substantially affect our estimates. Firstly, we re-estimate equation (14), our first step, allowing for an alternative and more flexible form of heterogeneity in the direct charter effect. Specifically, we interact charter attendance with dummies for being in Boston, in a non-Boston expanding district, being post-reform, being in Boston post-reform, and being in a non-Boston expanding district post-reform. While still not a fully flexible specification, this aims to directly account for the heterogeneity in $\tilde{\beta}_{idt} = \beta_{idt} - \rho C_{dt}$ induced by the quasi-random variation in C_{dt} that we take advantage of in our second (synthetic control) step.

Our second robustness check complements our main approach with a more standard approach based on different identifying assumptions. Specifically, we assume that selection into

[56] As far as we know, there is no official definition or test for overfitting. We use 10 as a threshold because some SC districts always have a very small weight when 10 districts belong to the SC.

charter schools following expansion is based on pre-expansion test scores and then use our 2SLS approach from section 6.2.2 to estimate the effect of charter expansion conditional on these scores. Formally, we model the achievement of non-charter students as

$$Y_{idt}^{0} = \alpha + \lambda C_{dt} + \delta Post_t + \theta E_d + \gamma' X_{idt} + \pi y_{id}^{pre} + \eta_d + u_{dt} + \varepsilon_{idt} \tag{15}$$

This is similar to equation 8, with E_d indicating an expanding district and $Post_t$ a post-expansion time period, but also includes an additional control for y_{id}^{pre} which is the student's most recent test score before the expansion. We identify C_{dt} with the assumption that ε_{idt} is uncorrelated with $Z_{dt} = E_d \times Post_t$ conditional on not attending a charter, which holds if student selection into charters is random conditional on y_{id}^{pre} and trends in potential outcomes are otherwise parallel.

We then estimate (15) by 2SLS in the sample of non-charter students in Boston and the non-expanding districts that make up the donor pool for our synthetic control analysis. Unlike in our previous analyses, we exclude non-Boston expanding districts as the instruments corresponding to these districts were no longer significant in the first stage when using this approach.

Both of these alternative approaches produce similar results. The first approach, using the alternative form of heterogeneity in the direct charter effect, produces extremely similar estimates of the district-by-time fixed effects as those estimated from equation (14) (the correlation is above 0.99). Thus, the results from synthetic control estimation using these fixed effects (shown in appendix figure A.3) are extremely similar. Appendix table A.10 reports the results from our second approach, the estimation of equation (15). These results are qualitatively similar to the main results we report in section 7, showing a positive and significant ($p < 0.05$)

effect of charter expansion on math scores and a smaller, insignificant effect on ELA scores.

Table A.10: Estimates of the effect of charter expansion on student test scores, controlling for pre-expansion test scores

	Math		ELA	
	First Stage	2SLS	First Stage	2SLS
	(1)	(2)	(3)	(4)
Charter Share		1.299*		0.477
		(0.529)		(0.499)
Post-reform * Boston	0.0500***		0.0500***	
	(0.00194)		(0.00194)	
N	418774	418774	415364	415364
First Stage F-Stat	662.972		663.419	
R2		0.785		0.733

† Notes: This table shows estimates of equation 15 by 2SLS, ie an IV-DiD regression of individual student achievement on charter share while controlling for pre-expansion test scores. All regressions control for district fixed effects and post-reform years. Charter share is an endogenous variable which ranges from 0 to 1. We instrument for charter share using an interaction between a dummy for being in a post-expansion reform year and a dummy for being in Boston.

Table A.11: Sensitivity Tests for Synthetic Control Specifications

	Specification name	Predictor variables	Number of lags	Variable weight method	Donor pool
		Outcomes: Districts' Per-Pupil Expenditures			
1	Cross-validation and all predictor var	Expenditures + charter share + Cov	-	Cross-validation	Bottom 20
2	Without cross-validation (4 lags)	Expenditures + charter share + Cov	4	No cross-val	Bottom 20
3	Without additional predictors	Expenditures + charter share	-	Cross-validation	Bottom 20
4	Without cross-validation (4 lags, no cov)	Expenditures + charter share	4	No cross-val	Bottom 20
5	Without cross-validation (all lags)	Expenditures + charter share + Cov	All	No cross-val	Bottom 20
6	Donor pool (DP) = bottom 25	Expenditures + charter share + Cov	-	Cross-validation	Bottom 25
7	Without cross-validation (DP = bottom 25)	Expenditures + charter share + Cov	4	No cross-val	Bottom 25
		Outcomes: Districts' Average Test Scores			
8	Cross-validation and all predictor var	Test score + charter share + Cov	-	Cross-validation	Bottom 25
9	Without cross-validation (4 lags)	Test scores + charter share + Cov	4	No cross-val	Bottom 25
10	Without additional predictors	Test scores + charter share	-	Cross-validation	Bottom 20
11	Without cross-validation (4 lags, no cov)	Test scores + charter share	4	No cross-val	Bottom 20
12	Without cross-validation (all lags)	Test scores + charter share + Cov	All	No cross-val	Bottom 20
13	Donor pool (DP) = bottom 20	Test scores + charter share + Cov	-	Cross-validation	Bottom 20
14	Without cross-validation (DP = bottom 20)	Test scores + charter share + Cov	4	No cross-val	Bottom 20

† Notes: This table presents the features of each synthetic control sensitivity test. For purposes of comparison, the first and second rows of each panel present the baseline specifications used throughout the paper. The specifications 1 and 8 are using cross-validation to compute districts weights. The specifications 2 and 9 differ from 1 and 8 because they do not use cross-validation. The specifications 3 and 10 use cross-validation but without additional predictor variables. For outcomes on districts' expenditures, the additional predictor variables are the percentage of black, Hispanic, female, special education, limited English proficient, subsidized lunch, and minority female students, as well as district size, an indicator for urban district, and average test scores. For outcomes on districts' test scores, the additional predictor variables (specification number 12) are districts' per-pupil total expenditures and per-pupil expenditures on fixed costs, instruction, support services, and salaries. The specifications 4 and 11 use neither cross-validation nor additional predictor variables. The specifications 5 and 12 include all lagged values, that is, the entire pre-reform path of the outcome variable and charter share as predictors (for the years 2002 to 2011). The specifications that include 4 years of lagged values include years 2003, 2005, 2008, and 2011 for the lags. The last two rows of each panel (6, 7, 13, and 14) are identical to the first two rows (the baseline specifications) with the exception that we change the donor pool. For fiscal outcomes, We enlarge the donor pool to districts whose students' test scores are in the bottom 25th percentile (instead of the bottom 20th percentile for the baseline specification).

Table A.12: Results of Sensitivity Tests for the Synthetic Control Specifications

		Number of SC districts (1)	RMSPE of the first stage (2)	RMSPE of the reduced form (3)	Treatment effect (reduced form) (4)
		Outcome: Districts' Transfers to Charter Schools			
1	Cross-validation and all predictor var	7	0.0043	0.2173	0.5718
2	Without cross-validation (4 lags)	6	0.0028	0.0769	0.5095
3	Without additional predictors	5	0.0019	0.1527	0.4724
4	Without cross-validation (4 lags, no cov)	6	0.0028	0.0769	0.5095
5	Without cross-validation (all lags)	6	0.0028	0.0769	0.5095
6	Donor pool (DP) = bottom 25	8	0.0115	0.1599	0.5810
7	Without cross-validation (DP = bottom 25)	8	0.0049	0.3275	0.5988
		Outcome: Districts' Temporary Refund			
1	Cross-validation and all predictor var	6	0.0113	0.3199	0.9094
2	Without cross-validation (4 lags)	7	0.0118	0.1324	0.9136
3	Without additional predictors	5	0.0044	0.2824	1.1819
4	Without cross-validation (4 lags, no cov)	7	0.0118	0.1324	0.9136
5	Without cross-validation (all lags)	7	0.0118	0.1324	0.9136
6	Donor pool (DP) = bottom 25	7	0.0111	0.1288	0.9207
7	Without cross-validation (DP = bottom 25)	5	0.0032	0.4023	0.9035
		Outcome: Districts' Per-Pupil Expenditures on Capital			
1	Cross-validation and all predictor var	13	0.0015	0.3494	0.0806
2	Without cross-validation (4 lags)	11	0.0022	0.1584	-0.1297
3	Without additional predictors	8	0.0026	0.3459	-0.1126
4	Without cross-validation (4 lags, no cov)	11	0.0022	0.1584	-0.1297
5	Without cross-validation (all lags)	11	0.0022	0.1584	-0.1297
6	Donor pool (DP) = bottom 25	11	0.0018	0.2062	-0.4370
7	Without cross-validation (DP = bottom 25)	11	0.0016	0.3383	-0.0182
		Outcome: Districts' Per-Pupil Expenditures on Instruction			
1	Cross-validation and all predictor var	10	0.0015	0.0228	0.0952
2	Without cross-validation (4 lags)	8	0.0023	0.0119	0.1115
3	Without additional predictors	7	0.0040	0.0228	0.1099
4	Without cross-validation (4 lags, no cov)	8	0.0023	0.0119	0.1115
5	Without cross-validation (all lags)	8	0.0023	0.0119	0.1115
6	Donor pool (DP) = bottom 25	8	0.0088	0.0132	0.1271
7	Without cross-validation (DP = bottom 25)	9	0.0022	0.0151	0.1054

† Notes: See next table.

Table A.13: Sensitivity Tests for the Synthetic Control Specifications (continued)

		Number of SC districts (1)	RMSPE of the first stage (2)	RMSPE of the reduced form (3)	Treatment effect (reduced form) (4)
		Outcome: Districts' Per-Pupil Expenditures on Salaries			
1	Cross-validation and all predictor var	11	0.0011	0.0196	0.0748
2	Without cross-validation (4 lags)	8	0.0011	0.0143	0.0788
3	Without additional predictors	11	0.0011	0.0173	0.0496
4	Without cross-validation (4 lags, no cov)	8	0.0011	0.0143	0.0788
5	Without cross-validation (all lags)	8	0.0011	0.0143	0.0788
6	Donor pool (DP) = bottom 25	7	0.0012	0.0145	0.0823
7	Without cross-validation (DP = bottom 25)	8	0.0012	0.0256	0.0639
		Outcome: Districts' Average Test Scores in Math			
1	Cross-validation and all predictor var	9	0.0023	0.0276	0.0133
2	Without cross-validation (4 lags)	5	0.0177	0.0156	0.0756
3	Without additional predictors	10	0.0026	0.0319	0.0580
4	Without cross-validation (4 lags, no cov)	10	0.0023	0.0153	0.0585
5	Without cross-validation (all lags)	10	0.0023	0.0153	0.0585
6	Donor pool (DP) = bottom 20	8	0.0018	0.0233	-0.0019
7	Without cross-validation (DP = bottom 20)	11	0.0019	0.0149	0.0578
		Outcome: Districts' Average Test Scores in ELA			
1	Cross-validation and all predictor var	10	0.0020	0.0350	0.0038
2	Without cross-validation (4 lags)	8	0.0240	0.0138	0.0354
3	Without additional predictors	10	0.0016	0.0461	-0.0167
4	Without cross-validation (4 lags, no cov)	31	0.0014	0.0229	-0.0019
5	Without cross-validation (all lags)	31	0.0014	0.0229	-0.0019
6	Donor pool (DP) = bottom 20	9	0.0018	0.0565	0.0297
7	Without cross-validation (DP = bottom 20)	8	0.0021	0.0132	0.0324
		Outcome: Student-Teacher Ratio			
1	Cross-validation and all predictor var	10	0.0018	0.3426	-0.0929
2	Without cross-validation (4 lags)	7	0.0021	0.2969	-0.1733
3	Without additional predictors	26	0.0015	0.2935	-0.0805
4	Without cross-validation (4 lags, no cov)	7	0.0021	0.2969	-0.1733
5	Without cross-validation (all lags)	7	0.0021	0.2969	-0.1733
6	Donor pool (DP) = bottom 25	8	0.0023	0.3167	-0.1886
7	Without cross-validation (DP = bottom 25)	8	0.0029	0.2790	-0.1813

† Notes: This table reports results of sensitivity tests done for the synthetic control method. For purposes of comparison, the first row of each panel presents the baseline specification used throughout the paper. The upper panel shows results when the outcome variable is districts' total per-pupil expenditures. Moving down the table, we document results when the outcome variable is districts' per-pupil expenditures on fixed costs, instruction, and support services, districts' average test scores in Math as well as english, language and arts (ELA), and the district-level student-teacher ratio. The first column shows the number of synthetic control districts identified by the synthetic control algorithm. The root mean squared prediction error (RMSPE) measures the fit quality between expanding districts' pre-reform path and nonexpanding districts' outcome path (column 2) and charter share path (column 3). In column 4, the reduced form treatment effect estimate is the average post-reform gap between the expanding districts' outcome and the weighted average outcome of the synthetic control districts.