Appendix A: Data

The data used for this project were provided by the NYC Department of Education (DOE). This Appendix describes the DOE data files and explains the process used to construct our working extract from these files.

A.1 Application Data

Data on NYC high school applications are controlled by the Student Enrollment Office. We received all applications for the 2003-2004 through 2006-2007 school years. Application records include students' rank-ordered lists of academic programs submitted in each round of the application process, along with school priorities and student attributes such as special education status, race, gender, and address. The raw application files contained all applications, including private school students and first-time ninth graders who wished to change schools as well as new high school applicants. From these records we selected the set of eighth graders who were enrolled as NYC public school students in the previous school year.

A.2 Enrollment Data

We received registration and enrollment files from the Office of School Performance and Accountability (OSPA). These data include every student's grade and building code, or school ID, as of October of each school year. A separate OSPA file contains biographical information, including many of the same demographic variables from the application data. We measure demographics from the application records for variables that appeared in both files and use the OSPA file to gather additional background information such as subsidized lunch status.

OSPA also provided an attendance file with days attended and absent for each student at every school he or she attended in a given year. We use these attendance records to assign students to ninth-grade schools. If a student was enrolled in multiple schools, we use the school with the greatest number of days attended in the year following their final application to high school. A final OSPA file included scores on New York State Education Department eighth grade achievement tests. We use these test scores to assign baseline math and English Language Arts (reading) scores. Baseline scores are normalized to have mean zero and standard deviation one in our applicant sample.

A.3 Outcome Data

Our analysis studies five outcomes: Regents math scores, PSAT scores, high school graduation, college attendance, and college quality. We next describe the construction of each of these outcomes.

The Regents math test is one of five tests NYC students must pass to receive a Regents high school diploma from the state of New York. We received records of scores on all Regents tests taken between

2004 and 2008. We measured Regents math scores based on the lowest level math test offered in each year, which changed over the course of our sample. For the first three cohorts the lowest level math test offered was the Math A (Elementary Algebra and Planar Geometry) test. In 2007, the Board of Regents began administering the Math E (Integrated Algebra I) exam in addition to the Math A exam; the latter was phased out completely by 2009. We assign the earliest high school score on either of these two exams as the Regents math outcome for students in our sample. The majority of students took Math A in tenth grade, while most students taking Math E did so in ninth grade.

PSAT scores were provided to the NYC DOE by the College Board for 2003-2012. We retain PSAT scores that include all three test sections: math, reading, and writing (some subtests are missing for some observations, particularly in earlier years of our sample). If students took the PSAT multiple times, we use the score from the first attempt.

High school graduation is measured from graduation files reporting discharge status for all public school students between 2005 and 2012. These files indicate the last school attended by each student and the reason for discharge, including graduation, equivalent achievement (e.g. receiving a general equivalency diploma), or dropout. Discharge status is reported in years 4, 5, and 6 from expected graduation based on a student's year of ninth grade enrollment; our data window ends in 2012, so we only observe 4-year and 5-year high school discharge outcomes for students enrolled in eighth grade for the 2006-2007 year. We therefore focus on 5-year graduation for all four cohorts. Our graduation outcome equals one if a student received either a local diploma, a Regents diploma, or an Advanced Regents diploma within 5 years of her expected graduation date. Students not present in the graduation files are coded as not graduating.

College outcomes are measured from National Student Clearinghouse (NSC) files. The NSC records enrollment for the vast majority of post-secondary institutions, though a few important New York City-area institutions, including Rutgers and Columbia University, were not included in the NSC during our sample period.[10] The NYC DOE submitted identifying information for all NYC students graduating between 2009 and 2012 for matching to the NSC. Since many students in the 2003-04 eighth grade cohort graduated in 2008, NSC data are missing for a large fraction of this cohort. Our college outcomes are therefore defined only for the last three cohorts in the sample. For these years we code a student as attending college if she enrolled in a post-secondary institution within five years of applying to high school. This captures students who graduated from high school on time and enrolled in college the following fall, as well as students that delayed high school graduation or college enrollment by one year.

We measure college quality based on the mean 2014 incomes of students enrolled in each institution among those born between 1980 and 1982. These average incomes are reported by Chetty et al. (2017b). Fewer than 100 observations in the NSC sample failed to match to institutions in the Chetty et al. (2017b) sample. For students who enrolled in multiple postsecondary institutions, we assign the quality of the first institution attended. If a student enrolled in multiple schools simultaneously, we use the institution with

[10]In addition, about 100 parents opted out of the NSC in 2011 and 2012.

the highest mean earnings.

A.4 Matching Data Files

To construct our final analysis sample, we begin with the set of high school applications submitted by students enrolled in eighth grade between the 2003-2004 and 2006-2007 school years. We match these applications to the student enrollment file using a unique student identifier known as the OSISID and retain individuals that appear as eighth graders in both data sets. If a student submits multiple high school applications as an eighth grader, we select the final application for which data is available. We then use the OSISID to match applicant records to the OSPA attendance and test scores files (used to assign ninth grade enrollment and baseline test scores), and the Regents, PSAT, graduation, and NSC outcome files.

This merged sample is used to construct the set of 316 high schools that enrolled at least 50 students with observations for each of the five outcomes, excluding selective schools that do not participate in the main DA round. The final choice sample includes the set of high school applicants reporting at least one of these 316 schools on their preference lists. The five outcome samples are subsets of the choice sample with observed data on the relevant outcome and enrolled in one of our sample high schools for ninth grade. Table A1 displays the impact of each restriction on sample size for the four cohorts in our analysis sample.

Appendix B: Econometric Methods

B.1 Rank-Ordered Control Functions

This section provides formulas for the rank-ordered control functions in equation (8). The choice model is

$$U_{ij} = \delta_{c(X_i)j} - \tau_{c(X_i)} D_{ij} + \eta_{ij} = V_{ij} + \eta_{ij},$$

where $V_{ij} \equiv \delta_{c(X_i)j} - \tau_{c(X_i)} D_{ij}$ represents the observed component of student i's utility for school j and η_{ij} is the unobserved component. The control functions are given by $\lambda_{ij} = E[\eta_{ij} - \mu_\eta | X_i, D_i, R_i] = E[\eta_{ij} | R_i, V_i] - \mu_\eta$, where $V_i = (V_{i1}, ..., V_{iJ})'$. To compute the conditional mean of η_{ij}, it will be useful to define the following functions for any set of mean utilities S and subset $S' \subseteq S$:

$$P\left(S'|S\right) = \frac{\sum_{v \in S'} \exp(v)}{\sum_{v \in S} \exp(v)},$$

$$\mathcal{I}(S) = \mu_\eta + \log\left(\sum_{v \in S} \exp(v)\right).$$

$P(S'|S)$ gives the probability that an individual chooses an option in S' from the set S when the value of each option is the sum of its mean utility and an extreme value type I error term, while $\mathcal{I}(S)$ gives the expected maximum utility of choosing an option in S, also known as the inclusive value. We provide expressions for the control functions for two cases: (1) when a student ranks all available alternatives, and (2) when the student leaves some alternatives unranked.

B.1.1 All alternatives ranked

Control function for the highest-ranked alternative

Without loss of generality label alternatives in decreasing order of student i's preferences, so that $R_{ij} = j$ for $j = 1...J$. The control function associated with the highest ranked alternative is

$$\lambda_{i1} = -(V_{i1} + \mu_\eta) + E\left[U_{i1} | R_i, V_i\right]$$

$$= -(V_{i1} + \mu_\eta) + \frac{\int_{-\infty}^{\infty} \int_{-\infty}^{u_1} \int_{-\infty}^{u_2} .... \int_{-\infty}^{u_{J-1}} \left[u_1 \prod_{j=1}^{J} f(u_j | V_{ij})\right] du_J ... du_2 du_1}{\prod_{j=1}^{J-1} P\left(V_{ij} | V_{ij} .... V_{iJ}\right)},$$

where $f(u|V) = \exp\left(V - u - \exp(V - u)\right)$ is the density function of a Gumbel random variable with location parameter V. This simplifies to

$$\lambda_{i1} = -(V_{i1} + \mu_\eta) + \frac{\prod_{j=1}^{J} P\left(V_{ij} | V_{ij} .... V_{iJ}\right) \times \mathcal{I}(V_{i1} ... V_{iJ})}{\prod_{j=1}^{J-1} P\left(V_{ij} | V_{ij} .... V_{iJ}\right)}.$$

$$= -V_{i1} + \left(\mathcal{I}(V_{i1} ... V_{iJ}) - \mu_\eta\right)$$

$$= -\log P(V_{i1}|V_{i1}...V_{iJ}),$$

which coincides with the control function for the best alternative in the multinomial logit model of Dubin and McFadden (1984). This shows that knowledge of the rankings of less-preferred alternatives does not affect the expected utility associated with the best choice.

Control functions for lower-ranked alternatives

To work out λ_{ij} for $j > 1$, define the following functions:

$$G_{i0}(u) = 1,$$

$$G_{ik}(u) = \int_u^\infty f(x|V_{ik})G_{i(k-1)}(x)dx,\ k = 1...J.$$

It can be shown that

$$G_{ik}(u) = \sum_{j=1}^{k} B_{ik}^{j}\left[1 - F(u|\mathcal{I}(V_j...V_k) - \mu_\eta)\right],$$

where $F(u|V) = \exp(-\exp(V-u))$ is the Gumbel CDF with location V, and the coefficients B_{ik}^j are:

$$B_{i1}^1 = 1,$$

$$B_{ik}^j = -B_{i(k-1)}^j \times P\left(V_{ik}|V_{ij}....V_{ik}\right),\ k > 1,\ j \neq k,$$

$$B_{ik}^k = \sum_{j=1}^{k-1} B_{i(k-1)}^j,\ k > 1.$$

Then for $j > 1$, we have

$$\lambda_{ij} = -(V_{ij} + \mu_\eta) + \frac{\int_{-\infty}^{\infty}\int_{u_j}^{\infty}\int_{u_{j-1}}^{\infty}...\int_{u_2}^{\infty}\int_{-\infty}^{u_j}\int_{-\infty}^{u_{j+1}}...\int_{-\infty}^{u_{J-1}}\left[u_j\prod_{k=1}^{J} f(u_k|V_{ik})\right]du_J...du_{j+1}du_1...du_j}{\prod_{k=1}^{J-1} P\left(V_{ik}|V_{ik}....V_{iJ}\right)}$$

$$= -(V_{ij} + \mu_\eta) + \frac{\int_{-\infty}^{\infty} u_j f(u_j|\mathcal{I}(V_{ij}...V_{iJ}) - \mu_\eta)G_{i(j-1)}(u_j)du_j}{\prod_{k=1}^{j-1} P\left(V_{ik}|V_{ik}....V_{iJ}\right)}$$

$$= -(V_{ij} + \mu_\eta) + \frac{\sum_{m=1}^{j-1} B_{i(j-1)}^{m}\left[\mathcal{I}(V_{ij}...V_{iJ}) - P(V_{ij}...V_{iJ}|V_{im}...V_{iJ})\mathcal{I}(V_{im}...V_{iJ})\right]}{\prod_{k=1}^{j-1} P\left(V_{ik}|V_{ik}....V_{iJ}\right)}.$$

B.1.2 Unranked alternatives

To derive the control functions for a case in which some alternatives are unranked, assign arbitrary labels $\ell(i)+1....J$ to unranked schools. The control functions for all ranked alternatives can be obtained by defining a composite unranked alternative with observed utility $V_{iu} = \mathcal{I}\left(V_{ik} : k > \ell(i)\right) - \mu_\eta$ and treating this as the lowest-ranked option in the calculations in section B.1.1. The control function for an unranked alternative $j > \ell(i)$ is defined by the expression

$$\lambda_{ij} + (V_{ij} + \mu_\eta) = E\left[U_{ij}|U_{i1} > ... > U_{i\ell(i)},\ U_{i\ell(i)} > U_{ik}\ \forall k > \ell(i), V_i\right]$$

$$= \frac{\int_{-\infty}^{\infty}\int_{u_j}^{\infty}\int_{u_{\ell(i)}}^{\infty}\int_{u_{\ell(i)-1}}^{\infty}...\int_{u_2}^{\infty}\int_{-\infty}^{u_{\ell(i)}}..\int_{-\infty}^{u_{\ell(i)}} u_j \prod_{k=1}^{J} f(u_k|V_{ik}) du_{\ell(i)+1} du_{j-1} du_{j+1}...du_J du_1...du_{\ell(i)} du_j}{\prod_{k=1}^{\ell(i)} P(V_{ik}|V_{ik}...V_{iJ})}$$

$$= \frac{\int_{-\infty}^{\infty} u_j f(u_j|V_{ij}) \left[\int_{u_j}^{\infty} f\left(u_{\ell(i)}|\mathcal{I}(S_i^{-j}(\ell(i))) - \mu_\eta\right) G_{i(\ell(i)-1)}(u_{\ell(i)}) du_{\ell(i)}\right] du_j}{P(V_{i\ell(i)}|S_i^{-j}(\ell(i)))^{-1} \times \prod_{k=1}^{\ell(i)} P(V_{ik}|V_{ik}...V_{iJ})},$$

where $S_i^{-j}(m) = \{V_{ik} : k \geq m\} \backslash \{V_{ij}\}$ is the set of i's mean utilities for alternatives m and higher excluding alternative j. When $\ell(i) = 1$, we have $G_{i(\ell(i)-1)}(u_\ell) = 1$ and this expression collapses to

$$\lambda_{ij} = \frac{P(V_{ij}|V_{i1}...V_{iJ})}{1 - P(V_{ij}|V_{i1}...V_{iJ})} \log P(V_{ij}|V_{i1}...V_{iJ}),$$

which is the expression derived by Dubin and McFadden (1984) for the expected errors of alternatives that are not selected in the multinomial logit model. For $\ell(i) > 1$, we have

$$\lambda_{ij} = -(V_{ij} + \mu_\eta)$$

$$+ \frac{\sum_{m=1}^{\ell(i)-1} B_{i(\ell(i)-1)}^m \left[(1 - P(S_i^{-j}(\ell(i))|S_i^{-j}(m)))\mathcal{I}(V_{ij}) - P(V_{ij}|V_{i\ell(i)}..V_{iJ})\mathcal{I}(V_{i\ell(i)}..V_{iJ}) + P(S_i^{-j}(\ell(i))|S_i^{-j}(m))P(V_{ij}|V_{im}..V_{iJ})\mathcal{I}(V_{im}..V_{iJ})\right]}{P(V_{i\ell(i)}|S_i^{-j}(\ell(i)))^{-1} \times \prod_{k=1}^{\ell(i)} P(V_{ik}|V_{ik}...V_{iJ})}.$$

B.2 Two-Step Score Bootstrap

We use a two-step modification of the score bootstrap of Kline and Santos (2012) to conduct inference for the control function models. Let $\Delta = (\delta_{11}...\delta_{1J}, \tau_1...\delta_{C1}...\delta_{CJ}, \tau_C)'$ denote the vector of choice model parameters for all covariate cells. Maximum likelihood estimates of these parameters are given by:

$$\hat{\Delta} = \arg\max_{\Delta} \sum_i \log \mathcal{L}(R_i|X_i, D_i; \Delta),$$

where $\mathcal{L}(R_i|X_i, D_i; \Delta)$ is the likelihood function defined in Section 4.1, now explicitly written as a function of the choice model parameters.

Let $\Gamma = (\alpha_1, \beta_1', \psi_1...\alpha_J, \beta_J', \psi_J, \gamma', \varphi)'$ denote the vector of outcome equation parameters. Second-step estimates of these parameters are

$$\hat{\Gamma} = \left[\sum_i W_i(\hat{\Delta}) W_i(\hat{\Delta})'\right]^{-1} \times \sum_i W_i(\hat{\Delta}) Y_i,$$

where $W_i(\Delta)$ is the vector of regressors in equation (8). This vector depends on Δ through the control functions $\lambda_j(X_i, D_i, R_i; \Delta)$, which in turn depend on the choice model parameters as described in Appendix B.1.

The two-step score bootstrap adjusts inference for the extra uncertainty introduced by the first-step estimates while avoiding the need to recalculate $\hat{\Delta}$ or to analytically derive the influence of $\hat{\Delta}$ on $\hat{\Gamma}$. The first step directly applies the approach in Kline and Santos (2012) to the choice model estimates. This approach generates a bootstrap distribution for $\hat{\Delta}$ by taking repeated Newton-Raphson steps from the full-sample estimates, randomly reweighting each observation's score contribution. The bootstrap estimate of Δ in trial $b \in \{1...B\}$ is:

$$\hat{\Delta}^b = \hat{\Delta} - \left[\sum_i \left(\frac{\partial^2 \log \mathcal{L}\big(R_i|X_i, D_i; \hat{\Delta}\big)}{\partial\Delta\partial\Delta'}\right)\right]^{-1} \times \sum_i \zeta_i^b \left(\frac{\partial \log \mathcal{L}(R_i|X_i, D_i; \hat{\Delta})}{\partial\Delta}\right),$$

where the ζ_i^b are *iid* random weights satisfying $E\left[\zeta_i^b\right] = 0$ and $E\left[(\zeta_i^b)^2\right] = 1$. We draw these weights from a standard normal distribution.

Next, we use an additional set of Newton-Raphson steps to generate a bootstrap distribution for $\hat{\Gamma}$. The second-step bootstrap estimates are:

$$\hat{\Gamma}^b = \hat{\Gamma} - \left[\sum_i W_i(\hat{\Delta})W_i(\hat{\Delta})'\right]^{-1} \times \sum_i \left[-\zeta_i^b W_i(\hat{\Delta})(Y_i - W_i(\hat{\Delta})'\hat{\Gamma}) - W_i(\hat{\Delta}^b)(Y_i - W_i(\hat{\Delta}^b)'\hat{\Gamma})\right].$$

The second term in the last sum accounts for the additional variability in the second-step score due to the first-step estimate $\hat{\Delta}$. We construct standard errors and conduct hypothesis tests involving Γ using the distribution of $\hat{\Gamma}^b$ across bootstrap trials.

B.3 Empirical Bayes Shrinkage

We next describe the empirical Bayes shrinkage procecure summarized in Section 4.2. Value-added or control function estimation produces a set of school-specific parameter estimates, $\left\{\hat{\theta}_j\right\}_{j=1}^J$. Under the hierarchical model (10), the likelihood of the estimates for school j conditional on the latent parameters θ_j and the sampling variance matrix Ω_j is:

$$\mathcal{L}\left(\hat{\theta}_j|\theta_j, \Omega_j\right) = (2\pi)^{-T/2} \left|\Omega_j\right|^{-1/2} \exp\left(-\tfrac{1}{2}(\hat{\theta}_j - \theta_j)'\Omega_j^{-1}(\hat{\theta}_j - \theta_j)\right),$$

where $T = \dim(\theta_j)$. We estimate Ω_j using conventional asymptotics for the value-added models and the bootstrap procedure described in Section B.2 for the control function models. Our approach therefore requires school-specific samples to be large enough for these asymptotic approximations to be accurate.

An integrated likelihood function that conditions only on the hyperparameters is:

$$\begin{aligned}\mathcal{L}^I(\hat{\theta}_j|\mu_\theta, \Sigma_\theta, \Omega_j) &= \int \mathcal{L}(\hat{\theta}_j|\theta_j, \Omega_j)dF(\theta_j|\mu_\theta, \Sigma_\theta) \\ &= (2\pi)^{-T/2} \left|\Omega_j + \Sigma_\theta\right|^{-1/2} \exp\left(-\tfrac{1}{2}(\hat{\theta}_j - \mu_\theta)'\left(\Omega_j + \Sigma_\theta\right)^{-1}(\hat{\theta}_j - \mu_\theta)\right).\end{aligned}$$

EB estimates of the hyperparameters are then

$$\left(\hat{\mu}_\theta, \hat{\Sigma}_\theta\right) = \arg\max_{\mu_\theta, \Sigma_\theta} \sum_j \log \mathcal{L}^I\left(\hat{\theta}_j|\mu_\theta, \Sigma_\theta, \hat{\Omega}_j\right),$$

where $\hat{\Omega}_j$ estimates Ω_j.

By standard arguments, the posterior distribution for θ_j given the estimate $\hat{\theta}_j$ is

$$\theta_j|\hat{\theta}_j \sim N\left(\theta_j^*, \Omega_j^*\right) ,$$

where

$$\theta_j^* = \left(\Omega_j^{-1} + \Sigma_\theta^{-1}\right)^{-1}\left(\Omega_j^{-1}\hat{\theta}_j + \Sigma_j^{-1}\mu_\theta\right),$$

$$\Omega_j^* = \left(\Omega_j^{-1} + \Sigma_\theta^{-1}\right)^{-1}.$$

We form EB posteriors by plugging $\hat{\Omega}_j$, $\hat{\mu}_\theta$ and $\hat{\Sigma}_\theta$ into these formulas.

Table A1. Sample restrictions

	All cohorts	2003-2004	2004-2005	2005-2006	2006-2007
	(1)	(2)	(3)	(4)	(5)
All NYC eighth graders	368,603	89,671	93,399	94,015	91,518
In public school	327,948	78,904	83,112	84,067	81,865
With baseline demographics	276,797	68,507	67,555	68,279	72,456
With address data	275,405	67,644	67,377	68,108	72,276
In preference sample	270,157	66,125	66,004	67,163	70,865
In Regents math sample	155,850	40,994	41,022	39,177	34,657
In PSAT sample	149,365	31,563	37,502	39,480	40,820
In high school graduation sample	230,087	56,833	56,979	57,803	58,472
In college sample	173,254	0	56,979	57,803	58,472

Notes: This table displays the selection criteria for inclusion in the final analysis samples. Preference models are estimated using the sample in the fourth row, and school effects are estimated using the samples in the remaining rows.

Table A2. Correlations of peer quality and treatment effect parameters for Regents math scores, value-added model

	Peer quality	Value-added parameters						
		ATE	Female	Black	Hispanic	Sub. lunch	Log tract inc.	Math score
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ATE	0.531							
	(0.042)							
Female	0.133	0.232						
	(0.077)	(0.082)						
Black	-0.033	-0.007	-0.287					
	(0.074)	(0.082)	(0.133)					
Hispanic	-0.002	-0.028	-0.414	0.939				
	(0.077)	(0.086)	(0.135)	(0.022)				
Subsidized lunch	0.093	-0.133	0.098	-0.027	0.065			
	(0.088)	(0.097)	(0.145)	(0.151)	(0.155)			
Log census tract income	-0.288	-0.108	-0.210	-0.140	-0.048	-0.200		
	(0.111)	(0.129)	(0.185)	(0.202)	(0.212)	(0.220)		
Eighth grade math score	-0.108	0.033	-0.104	-0.005	0.054	0.012	-0.083	
	(0.064)	(0.069)	(0.098)	(0.100)	(0.105)	(0.118)	(0.150)	
Eighth grade reading score	-0.564	-0.425	-0.036	-0.065	-0.064	0.071	0.374	0.244
	(0.065)	(0.079)	(0.124)	(0.123)	(0.130)	(0.134)	(0.181)	(0.103)

Notes: This table reports estimated correlations between peer quality and school treatment effect parameters for Regents math scores. The ATE is a school's average treatment effect, and other treatment effect parameters are school-specific interactions with student characteristics. Estimates come from maximum likelihood models fit to school-specific regression coefficients from a value-added model controlling for observed characteristics.

Table A3. Joint distribution of peer quality and treatment effect parameters for PSAT scores/10

		Peer quality (1)	Control function parameters ATE (2)	Female (3)	Black (4)	Hispanic (5)	Sub. lunch (6)	Log tract inc. (7)	Math score (8)	Reading score (9)	Pref. coef. (10)
Mean		0	0	-0.033	-0.284	-0.259	-0.006	-0.005	0.963	1.032	-0.003
		-	-	(0.010)	(0.026)	(0.027)	(0.011)	(0.010)	(0.016)	(0.011)	(0.001)
Standard deviation		0.884	0.401	0.111	0.333	0.352	0.111	0.059	0.240	0.152	0.017
		(0.056)	(0.048)	(0.012)	(0.023)	(0.026)	(0.017)	(0.022)	(0.016)	(0.073)	(0.011)
Correlations:	ATE	0.979									
		(0.086)									
	Female	-0.251	-0.315								
		(0.094)	(0.068)								
	Black	-0.130	-0.253	0.020							
		(0.124)	(0.090)	(0.160)							
	Hispanic	-0.168	-0.274	0.112	0.932						
		(0.094)	(0.079)	(0.150)	(0.123)						
	Subsidized lunch	-0.197	-0.211	0.252	-0.131	-0.120					
		(0.144)	(0.101)	(0.117)	(0.135)	(0.124)					
	Log census tract income	0.198	0.280	-0.228	-0.183	-0.122	-0.545				
		(0.219)	(0.212)	(0.241)	(0.264)	(0.247)	(0.276)				
	Eighth grade math score	0.709	0.701	-0.117	-0.005	-0.090	-0.099	0.022			
		(0.123)	(0.102)	(0.093)	(0.125)	(0.108)	(0.135)	(0.220)			
	Eighth grade reading score	0.164	0.249	-0.219	0.011	-0.084	0.108	0.446	0.246		
		(0.230)	(0.121)	(0.074)	(0.067)	(0.065)	(0.072)	(0.198)	(0.287)		
	Preference coefficient (ψ_j)	0.377	0.291	-0.159	-0.114	-0.062	-0.157	0.334	0.100	-0.109	
		(0.280)	(0.145)	(0.039)	(0.038)	(0.055)	(0.066)	(0.117)	(0.074)	(0.105)	

Notes: This table shows the estimated joint distribution of peer quality and school treatment effect parameters for PSAT scores divded by 10. The ATE is a school's average treatment effect, and other treatment effect parameters are school-specific interactions with student characteristics. Estimates come from maximum likelihood models fit to school-specific regression coefficients from a control function model controlling for observed characteristics, distance to school and unobserved tastes from the choice model.

Table A4. Joint distribution of peer quality and treatment effect parameters for high school graduation

		Peer quality	Control function parameters								
			ATE	Female	Black	Hispanic	Sub. lunch	Log tract inc.	Math score	Reading score	Pref. coef.
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Mean		0	0	0.063	-0.006	-0.013	-0.013	0.002	0.132	0.062	0.000
		-	-	(0.004)	(0.007)	(0.008)	(0.003)	(0.003)	(0.003)	(0.002)	(0.000)
Standard deviation		0.100	0.043	0.047	0.090	0.103	0.024	0.024	0.034	0.027	0.006
		(0.004)	(0.008)	(0.004)	(0.007)	(0.007)	(0.003)	(0.004)	(0.002)	(0.002)	(0.000)
Correlations:	ATE	0.590									
		(0.106)									
	Female	-0.072	-0.549								
		(0.070)	(0.170)								
	Black	-0.226	-0.296	-0.069							
		(0.069)	(0.195)	(0.142)							
	Hispanic	-0.174	-0.237	-0.078	0.956						
		(0.067)	(0.196)	(0.135)	(0.013)						
	Subsidized lunch	0.169	-0.120	0.119	0.171	0.264					
		(0.096)	(0.238)	(0.169)	(0.180)	(0.176)					
	Log census tract income	0.039	0.032	-0.412	-0.113	-0.168	0.177				
		(0.103)	(0.244)	(0.154)	(0.196)	(0.193)	(0.203)				
	Eighth grade math score	-0.396	-0.619	0.075	-0.168	-0.114	0.051	0.036			
		(0.060)	(0.166)	(0.098)	(0.109)	(0.107)	(0.128)	(0.134)			
	Eighth grade reading score	-0.571	-0.570	-0.125	0.188	0.094	-0.194	0.140	0.475		
		(0.059)	(0.180)	(0.112)	(0.136)	(0.134)	(0.153)	(0.157)	(0.103)		
	Preference coefficient (ψ_j)	0.625	0.437	0.123	-0.110	-0.049	0.021	-0.117	-0.246	-0.470	
		(0.044)	(0.180)	(0.084)	(0.089)	(0.086)	(0.120)	(0.123)	(0.078)	(0.078)	

Notes: This table shows the estimated joint distribution of peer quality and school treatment effect parameters for high school graduation. The ATE is a school's average treatment effect, and other treatment effect parameters are school-specific interactions with student characteristics. Estimates come from maximum likelihood models fit to school-specific regression coefficients from a control function model controlling for observed characteristics, distance to school and unobserved tastes from the choice model.

Table A5. Joint distribution of peer quality and treatment effect parameters for college attendance

		Peer	Control function parameters								
		quality	ATE	Female	Black	Hispanic	Sub. lunch	Log tract inc.	Math score	Reading score	Pref. coef.
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Mean		0	0	0.075	-0.010	-0.011	-0.008	0.002	0.118	0.064	-0.002
		-	-	(0.003)	(0.009)	(0.009)	(0.003)	(0.003)	(0.002)	(0.002)	(0.000)
Standard deviation		0.099	0.053	0.035	0.122	0.120	0.031	0.019	0.030	0.024	0.005
		(0.118)	(0.022)	(0.004)	(0.009)	(0.009)	(0.005)	(0.007)	(0.013)	(0.009)	(0.002)
Correlations:	ATE	0.862									
		(0.158)									
	Female	-0.074	-0.307								
		(0.017)	(0.031)								
	Black	-0.035	-0.455	0.040							
		(0.021)	(0.066)	(0.160)							
	Hispanic	-0.135	-0.471	-0.024	0.947						
		(0.019)	(0.031)	(0.043)	(0.019)						
	Subsidized lunch	0.110	0.235	-0.005	-0.390	-0.339					
		(0.027)	(0.078)	(0.139)	(0.119)	(0.117)					
	Log census tract income	-0.215	0.127	-0.182	-0.722	-0.674	0.316				
		(0.065)	(0.238)	(0.287)	(0.246)	(0.241)	(0.242)				
	Eighth grade math score	-0.204	-0.188	0.265	-0.067	-0.028	0.073	-0.437			
		(0.073)	(0.179)	(0.074)	(0.073)	(0.056)	(0.110)	(0.129)			
	Eighth grade reading score	-0.290	-0.121	-0.131	-0.346	-0.364	-0.198	0.217	0.304		
		(0.112)	(0.197)	(0.078)	(0.083)	(0.082)	(0.105)	(0.219)	(0.171)		
	Preference coefficient (ψ_j)	0.770	0.524	0.144	0.106	0.059	0.003	-0.210	-0.072	-0.314	
		(0.119)	(0.130)	(0.068)	(0.056)	(0.057)	(0.129)	(0.233)	(0.238)	(0.183)	

Notes: This table shows the estimated joint distribution of peer quality and school treatment effect parameters for college attendance. The ATE is a school's average treatment effect, and other treatment effect parameters are school-specific interactions with student characteristics. Estimates come from maximum likelihood models fit to school-specific regression coefficients from a control function model controlling for observed characteristics, distance to school and unobserved tastes from the choice model.

Table A6. Joint distribution of peer quality and treatment effect parameters for log college quality

		Peer quality	Control function parameters								
			ATE	Female	Black	Hispanic	Sub. lunch	Log tract inc.	Math score	Reading score	Pref. coef.
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Mean		0	0	0.048	-0.037	-0.035	-0.006	-0.001	0.103	0.058	-0.002
		-	-	(0.002)	(0.006)	(0.006)	(0.002)	(0.002)	(0.002)	(0.002)	(0.000)
Standard deviation		0.097	0.063	0.027	0.081	0.084	0.022	0.013	0.031	0.019	0.004
		(0.078)	(0.017)	(0.003)	(0.006)	(0.006)	(0.004)	(0.004)	(0.010)	(0.006)	(0.004)
Correlations:	ATE	0.931									
		(0.051)									
	Female	0.114	0.084								
		(0.018)	(0.021)								
	Black	-0.065	-0.258	-0.023							
		(0.019)	(0.029)	(0.157)							
	Hispanic	-0.239	-0.354	-0.127	0.946						
		(0.018)	(0.021)	(0.059)	(0.048)						
	Subsidized lunch	-0.063	0.060	0.253	-0.334	-0.208					
		(0.035)	(0.038)	(0.082)	(0.085)	(0.071)					
	Log census tract income	0.030	-0.028	-0.333	-0.529	-0.553	0.036				
		(0.060)	(0.068)	(0.121)	(0.132)	(0.135)	(0.109)				
	Eighth grade math score	0.533	0.728	0.381	-0.143	-0.151	0.146	-0.550			
		(0.078)	(0.063)	(0.054)	(0.072)	(0.040)	(0.066)	(0.151)			
	Eighth grade reading score	0.296	0.479	-0.027	-0.266	-0.275	-0.355	0.089	0.466		
		(0.064)	(0.033)	(0.018)	(0.019)	(0.020)	(0.046)	(0.088)	(0.070)		
	Preference coefficient (ψ_j)	0.750	0.623	0.135	0.033	-0.061	-0.086	0.139	0.310	0.161	
		(0.076)	(0.041)	(0.008)	(0.019)	(0.009)	(0.021)	(0.050)	(0.059)	(0.033)	

Notes: This table shows the estimated joint distribution of peer quality and school treatment effect parameters for college quality. The ATE is a school's average treatment effect, and other treatment effect parameters are school-specific interactions with student characteristics. Estimates come from maximum likelihood models fit to school-specific regression coefficients from a control function model controlling for observed characteristics, distance to school and unobserved tastes from the choice model.

Table A7. Preferences, peer quality, and math effects, alternative measures of popularity

	Log first-choice share		Minus log sum of ranks	
	Value-added	Control function	Value-added	Control function
	(1)	(2)	(3)	(4)
Peer quality	0.487	0.542	0.036	0.038
	(0.071)	(0.062)	(0.005)	(0.005)
ATE	-0.009	-0.034	-0.001	-0.002
	(0.045)	(0.040)	(0.003)	(0.003)
Match effect	-0.091	-0.219	-0.004	-0.012
	(0.043)	(0.047)	(0.003)	(0.004)
N	15892		21684	

Notes: This table reports estimates from regressions of alternative measures of school popularity on peer quality and school effectiveness. The dependent variable in columns (1) and (2) is the log of the share of students in a covariate cell ranking each school first, and the dependent variable in columns (3) and (4) is minus the log of the sum of ranks for students in the cell. Unranked schools are assigned one rank below the least-preferred ranked school. Covariate cells are defined by borough, gender, race, subsidized lunch status, an indicator for students above the median of census tract median income, and tercile of the average of eighth grade math and reading scores. Peer quality is constructed as the average predicted Regents math score for enrolled students. Treatment effect estimates are empirical Bayes posterior mean predictions of Regents math effects. Columns (1) and (3) report results from value-added models, while columns (2) and (4) report results from control function models. All regressions include cell indicators. Standard errors are double-clustered by school and covariate cell.

Table A8. Preferences for peer quality and Regents math effects among students ranking fewer than 12 choices

	Value-added models				Control function models			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Peer quality	0.452		0.487	0.445	0.445		0.491	0.485
	(0.071)		(0.073)	(0.077)	(0.065)		(0.067)	(0.068)
ATE		0.276	-0.052	-0.040		0.250	-0.073	-0.073
		(0.053)	(0.053)	(0.054)		(0.052)	(0.049)	(0.049)
Match effect				-0.092				-0.184
				(0.050)				(0.055)
N	20898							

Notes: This table reports estimates from regressions of school popularity on peer quality and school effectiveness, restricted to the subsample of students who ranked fewer than 12 programs. School popularity is measured as the estimated mean utility for each school and covariate cell in the choice model from Table 4. Covariate cells are defined by borough, gender, race, subsidized lunch status, an indicator for students above the median of census tract median income, and tercile of the average of eighth grade math and reading scores. Peer quality is constructed as the average predicted Regents math score for enrolled students. Treatment effect estimates are empirical Bayes posterior mean predictions of Regents math effects. Mean utilities, peer quality, and treatment effects are scaled in standard deviation units. Columns (1)-(4) report results from value-added models, while columns (5)-(8) report results from control function models. All regressions include cell indicators and weight by the inverse of the squared standard error of the mean utility estimates. Standard errors are double-clustered by school and covariate cell.

Table A9. Preferences, peer quality, and math effects, alternative treatment effect models

	Matched first choice model				Distance instrument model			
	(1)	(2)	(3)	(4)				
Peer quality	0.367		0.400	0.406	0.397		0.402	0.408
	(0.053)		(0.054)	(0.067)	(0.058)		(0.060)	(0.060)
ATE		0.209	-0.058	-0.036		0.236	-0.009	-0.027
		(0.045)	(0.043)	(0.045)		(0.046)	(0.044)	(0.045)
Match effect				-0.092				-0.129
				(0.049)				(0.041)
N	21684							

Notes: This table reports estimates from regressions of school popularity on peer quality and alternative measures of school effectiveness. Estimates in columns (1)-(4) come from an OLS regression of Regents math scores on school indicators interacted with covariates, with controls for distance and fixed effects for first choice schools. Estimates in columns (5)-(8) come from a regression of Regents math scores on school indicators interacted with covariates and control functions measuring mean preferences for each school, excluding distance controls. School popularity is measured as the estimated mean utility for each school and covariate cell in the choice model from Table 4. Covariate cells are defined by borough, gender, race, subsidized lunch status, an indicator for students above the median of census tract median income, and tercile of the average of eighth grade math and reading scores. Peer quality is constructed as the average predicted Regents math score for enrolled students. Treatment effect estimates are empirical Bayes posterior mean predictions of Regents math effects. Mean utilities, peer quality, and treatment effects are scaled in standard deviation units. All regressions include cell indicators and weight by the inverse of the squared standard error of the mean utility estimates. Standard errors are double-clustered by school and covariate cell.

Table A10. Potential achievement gains from ranking schools by effectiveness, by baseline test score quartile

	Observed rankings			Rankings based on effectiveness			Increase in
	Peer quality	ATE	Match	Peer quality	ATE	Match	effectiveness
Baseline quartile	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Lowest	-0.084	0.015	0.015	0.312	0.452	0.356	0.779
Second	0.011	0.042	0.005	0.395	0.469	0.122	0.545
Third	0.127	0.074	-0.011	0.329	0.464	0.018	0.419
Highest	0.399	0.155	-0.157	0.106	0.324	0.149	0.475

Notes: This table summarizes Regents math score gains that parents could achieve by ranking schools based on effectiveness., separately by baseline math score quartile. Columns (1)-(3) report average peer quality, average treatment effects, and average match effects for schools ranked first by students in each quartile. Columns (4)-(6) display corresponding statistics for hypothetical rankings that list schools in order of their treatment effects. Column (7) reports the difference in treatment effects (ATE+match) between the top-ranked school when rankings are based on effectiveness and the observed top-ranked school. Treatment effect estimates come from control function models. All calculations are restricted to ranked schools within the home borough.