

# Online Appendix —When Opportunity Costs Others: The Spillover Effects of School Choice Lotteries on Criminality\*

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# Online Appendix A Tables and Figures

Table A1: Outcomes Summary

|                                  | CMS             | Lottery Apps    | Non-Applicants  |
|----------------------------------|-----------------|-----------------|-----------------|
| <i>A) Crime Outcomes</i>         |                 |                 |                 |
| Pr(Any Arrest)                   | 0.13<br>(0.33)  | 0.11<br>(0.31)  | 0.12<br>(0.33)  |
| Pr(Violent Arrests)              | 0.08<br>(0.27)  | 0.07<br>(0.25)  | 0.07<br>(0.26)  |
| Pr(Incarceration)                | 0.08<br>(0.26)  | 0.06<br>(0.24)  | 0.07<br>(0.26)  |
| Num. Arrests                     | 0.49<br>(2.00)  | 0.40<br>(1.78)  | 0.45<br>(1.90)  |
| Num. Violent Arrests             | 0.21<br>(0.96)  | 0.18<br>(0.93)  | 0.18<br>(0.88)  |
| Days Incarcerated                | 8.95<br>(60.88) | 6.41<br>(49.08) | 7.50<br>(54.03) |
| <i>B) Other Student Outcomes</i> |                 |                 |                 |
| Reading Test Scores (6th-8th)    | -0.06<br>(1.06) | 0.18<br>(0.94)  | -0.03<br>(1.06) |
| Math Test Scores (6th-8th)       | 0.05<br>(1.09)  | 0.23<br>(1.00)  | 0.10<br>(1.11)  |
| Days Suspended                   | 2.86<br>(7.66)  | 2.17<br>(6.02)  | 2.71<br>(7.50)  |
| Days Absent                      | 6.28<br>(7.56)  | 5.25<br>(5.97)  | 6.28<br>(7.54)  |
| Graduated HS                     | 0.91<br>(0.28)  | 0.96<br>(0.21)  | 0.91<br>(0.28)  |
| Dropped Out of HS                | 0.09<br>(0.28)  | 0.05<br>(0.21)  | 0.09<br>(0.29)  |
| Num. of Students in Sample       | 13,491          | 1,802           | 8,563           |

Notes: Panel A includes the summary statistics of each arrest and incarceration outcome from age 16 to 22 for our main sample of male 5th grade students in Charlotte-Mecklenburg Schools (CMS) between the years of 2005-2006 to 2007-2008. The columns show means and standard deviations for CMS, the sample of lottery applicants and the non-applicant sample, respectively. Panel B includes means and standard deviations for other student outcomes for the same three samples. The last row refers to the number of students in each sample. The number of observations contributing to each mean in Panel B varies.

Table A2: Applicant Summary by Attendance

|                               | Lottery Winners |                 |                |                     |                | Lottery Losers |                 |                |                     |                |
|-------------------------------|-----------------|-----------------|----------------|---------------------|----------------|----------------|-----------------|----------------|---------------------|----------------|
|                               | All             | Att. App<br>Yes | App<br>No      | Att. Neighb.<br>Yes | Neighb.<br>No  | All            | Att. App<br>Yes | App<br>No      | Att. Neighb.<br>Yes | Neighb.<br>No  |
| Attend HS (Grade 6)           | 0.03<br>(0.18)  | 0.01<br>(0.08)  | 0.15<br>(0.36) | 1.00<br>(0.00)      | 0.00<br>(0.00) | 0.39<br>(0.49) | 0.03<br>(0.16)  | 0.45<br>(0.50) | 1.00<br>(0.00)      | 0.00<br>(0.00) |
| Attend App 1 Schl (Grade 6)   | 0.83<br>(0.38)  | 1.00<br>(0.00)  | 0.00<br>(0.00) | 0.18<br>(0.39)      | 0.85<br>(0.36) | 0.14<br>(0.35) | 1.00<br>(0.00)  | 0.00<br>(0.00) | 0.01<br>(0.10)      | 0.23<br>(0.42) |
| Attend App 2/3 Schl (Grade 6) | 0.35<br>(0.48)  | 0.36<br>(0.48)  | 0.34<br>(0.47) | 0.27<br>(0.46)      | 0.35<br>(0.48) | 0.31<br>(0.46) | 0.36<br>(0.48)  | 0.30<br>(0.46) | 0.24<br>(0.43)      | 0.35<br>(0.48) |
| Magnet First Choice           | 0.75<br>(0.43)  | 0.76<br>(0.43)  | 0.72<br>(0.45) | 0.77<br>(0.43)      | 0.75<br>(0.43) | 0.75<br>(0.43) | 0.70<br>(0.46)  | 0.76<br>(0.43) | 0.80<br>(0.40)      | 0.72<br>(0.45) |
| Made Second Choice            | 0.80<br>(0.40)  | 0.78<br>(0.41)  | 0.86<br>(0.35) | 0.73<br>(0.46)      | 0.80<br>(0.40) | 0.80<br>(0.40) | 0.77<br>(0.42)  | 0.81<br>(0.39) | 0.78<br>(0.41)      | 0.81<br>(0.39) |
| Made Third Choice             | 0.54<br>(0.50)  | 0.52<br>(0.50)  | 0.62<br>(0.49) | 0.68<br>(0.48)      | 0.54<br>(0.50) | 0.55<br>(0.50) | 0.49<br>(0.50)  | 0.56<br>(0.50) | 0.50<br>(0.50)      | 0.58<br>(0.49) |
| Black                         | 0.45<br>(0.50)  | 0.45<br>(0.50)  | 0.47<br>(0.50) | 0.64<br>(0.49)      | 0.45<br>(0.50) | 0.57<br>(0.50) | 0.46<br>(0.50)  | 0.58<br>(0.49) | 0.56<br>(0.50)      | 0.57<br>(0.50) |
| White                         | 0.36<br>(0.48)  | 0.37<br>(0.48)  | 0.33<br>(0.47) | 0.23<br>(0.43)      | 0.37<br>(0.48) | 0.24<br>(0.43) | 0.33<br>(0.47)  | 0.23<br>(0.42) | 0.25<br>(0.43)      | 0.24<br>(0.43) |
| Hispanic                      | 0.09<br>(0.29)  | 0.08<br>(0.28)  | 0.13<br>(0.34) | 0.05<br>(0.21)      | 0.09<br>(0.29) | 0.12<br>(0.32) | 0.11<br>(0.31)  | 0.12<br>(0.32) | 0.10<br>(0.30)      | 0.13<br>(0.33) |
| Ec. Disadvantage              | 0.40<br>(0.49)  | 0.37<br>(0.48)  | 0.52<br>(0.50) | 0.55<br>(0.51)      | 0.39<br>(0.49) | 0.50<br>(0.50) | 0.40<br>(0.49)  | 0.52<br>(0.50) | 0.47<br>(0.50)      | 0.52<br>(0.50) |
| Math (Grade 4)                | 0.45<br>(0.98)  | 0.47<br>(0.96)  | 0.32<br>(1.05) | 0.39<br>(1.02)      | 0.45<br>(0.98) | 0.23<br>(0.95) | 0.43<br>(0.91)  | 0.19<br>(0.96) | 0.23<br>(0.97)      | 0.22<br>(0.94) |
| Read (Grade 4)                | 0.34<br>(0.91)  | 0.37<br>(0.89)  | 0.18<br>(0.96) | -0.01<br>(0.90)     | 0.35<br>(0.90) | 0.15<br>(0.91) | 0.39<br>(0.76)  | 0.12<br>(0.93) | 0.15<br>(0.92)      | 0.16<br>(0.91) |
| Missing test score            | 0.04<br>(0.20)  | 0.04<br>(0.20)  | 0.06<br>(0.24) | 0.05<br>(0.21)      | 0.04<br>(0.20) | 0.04<br>(0.20) | 0.01<br>(0.11)  | 0.05<br>(0.21) | 0.04<br>(0.19)      | 0.04<br>(0.21) |
| ELL                           | 0.04<br>(0.20)  | 0.04<br>(0.19)  | 0.06<br>(0.24) | 0.05<br>(0.21)      | 0.04<br>(0.20) | 0.06<br>(0.23) | 0.07<br>(0.25)  | 0.06<br>(0.23) | 0.06<br>(0.23)      | 0.06<br>(0.23) |
| Observations                  | 685             | 566             | 119            | 22                  | 663            | 1,117          | 159             | 958            | 436                 | 681            |
| Proportion                    |                 | 0.83            | 0.17           | 0.03                | 0.97           |                | 0.14            | 0.86           | 0.39                | 0.61           |

Notes: Summary of applicants by application school and neighborhood school attendance. The first five columns show means and standard deviations for lottery winners, winners who do and do not attend the applications school in 6th grade, and winners who do and do not attend the initially assigned neighborhood school in 6th grade. The last five columns display the means and standard deviations for the analogous groups of lottery losers. *ELL* is an indicator for English Language Learner. *Ec. Disadvantage* is an indicator for economically disadvantaged. *Test Miss* is an indicator for missing either test score.

Table A3: Correlation Between Wins and Expected Wins

|               | Individual Level    |                     |                     | Group Level         |                     |                     |
|---------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
|               | No Controls         | CBG FE              | All FE              | No Controls         | CBG FE              | All FE              |
| E[W]          | 0.948***<br>(0.060) | 0.935***<br>(0.073) | 0.931***<br>(0.075) | 0.948***<br>(0.060) | 0.935***<br>(0.085) | 0.931***<br>(0.088) |
| Observations  | 8563                | 8563                | 8563                | 1154                | 1134                | 1134                |
| P-Value       | .384                | .374                | .356                | .384                | .443                | .433                |
| SD(Residuals) | .676                | .503                | .496                | .542                | .456                | .455                |

Notes: Estimated regression coefficients from regressing the number of wins on expected number of wins. Estimated at the individual and group levels with no controls, CBG fixed effects only, and all fixed effects (CBG, Cohort, and School). Group level regressions are weighted by the number of sample observations in group. The P-values are for tests against the null hypothesis that the coefficient is 1. Standard deviations of residuals are included in the last row.

Table A4: Power Analysis for Reduced Form, Rejection Rates (5%)

|                                                  | Pooled    |           | High-Risk |           | Low-Risk  |           |
|--------------------------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                                  | One sided | Two sided | One sided | Two sided | One sided | Two sided |
| <i>Panel A: Effect Size = 20% of Sample Mean</i> |           |           |           |           |           |           |
| Any Arrest                                       | .873      | .816      | .590      | .478      | .864      | .786      |
| Any Violent Arrest                               | .682      | .602      | .391      | .303      | .764      | .686      |
| Any Incarceration                                | .704      | .621      | .408      | .309      | .779      | .686      |
| N Arrests                                        | .614      | .512      | .343      | .239      | .793      | .703      |
| N Violent Arrests                                | .545      | .446      | .311      | .209      | .735      | .651      |
| Days Incarcerated                                | .388      | .297      | .208      | .145      | .711      | .618      |
| <i>Panel B: Effect Size = 30% of Sample Mean</i> |           |           |           |           |           |           |
| Any Arrest                                       | .984      | .977      | .836      | .761      | .976      | .962      |
| Any Violent Arrest                               | .917      | .866      | .626      | .514      | .943      | .919      |
| Any Incarceration                                | .902      | .860      | .635      | .538      | .944      | .910      |
| N Arrests                                        | .826      | .759      | .541      | .445      | .937      | .906      |
| N Violent Arrests                                | .774      | .691      | .469      | .363      | .919      | .881      |
| Days Incarcerated                                | .598      | .504      | .333      | .224      | .887      | .837      |

Notes: Rejection rates at 5% level from bootstrap analysis. Panels A and B are for effect sizes equal to 20% and 30% of the sample means, respectively. Each bootstrap sample draws random clusters in the exposed and unexposed sub samples, then random samples within cluster. Treatments = (wins, expected wins) pairs are randomly drawn from the distribution of sample treatments for the exposed bootstrap samples. 1000 repetitions.

Table A5: Effects of Peer Wins on Attendance and Movement

|                         | Attend            |                  | Exit              |                   |
|-------------------------|-------------------|------------------|-------------------|-------------------|
|                         | Neighb. Sch.      | Change NS        | Grade 6           | Grade 9           |
| <i>Panel A: Pooled</i>  |                   |                  |                   |                   |
| N Wins                  | -0.014<br>(0.014) | 0.021<br>(0.016) | -0.002<br>(0.006) | -0.005<br>(0.009) |
| Sample Mean             | .777              | .232             | .11               | .256              |
| N                       | 8563              | 8563             | 8563              | 8563              |
| <i>Panel B: By Risk</i> |                   |                  |                   |                   |
| N Wins $\times$ HR      | -0.007<br>(0.014) | 0.022<br>(0.018) | 0.001<br>(0.010)  | -0.009<br>(0.013) |
| N Wins $\times$ LR      | -0.021<br>(0.021) | 0.022<br>(0.022) | -0.004<br>(0.008) | -0.002<br>(0.011) |
| Observations            | 8563              | 8563             | 8563              | 8563              |

Notes: Estimated effect of wins on non-applicant outcomes. Panel A includes estimates from the full sample. Panel B reports the same set of estimates for the high- and low-risk students, based on the estimated probability of arrest.  $Wins \times HR$  shows estimates for the group with higher than median estimated risk, and  $Wins \times LR$  shows estimates for the group with lower than median estimated risk. Panel B is estimated using interaction terms between win proportion and high- and low-risk. All regressions include CBG fixed effects. Panel A regressions condition on the number of expected wins and Panel B regressions include interaction terms between risk indicators and expected wins, as well as a risk indicator. *Attend Neighb. Sch.* indicates whether the student attended their initially assigned neighborhood school in 6th grade. *Change NS* = Designated neighborhood school changes from year of lottery to the next year, indicating likely residential movement. *Exit* = Missing sixth grade school of attendance in CMS data, or missing 9th grade school of attendance in CMS data, which indicate likely district exit. Standard errors are clustered at the CBG-Neighborhood School-Cohort level.

Table A6: Effect of Peer Wins on Intensive Margin - Poisson

|                               | All<br>Arrests      | Violent<br>Arrests  | Days<br>Incarc.     |
|-------------------------------|---------------------|---------------------|---------------------|
| <i>Panel A: Pooled</i>        |                     |                     |                     |
| N Wins                        | 0.102<br>(0.082)    | 0.083<br>(0.081)    | 0.155<br>(0.111)    |
| Observations                  | 7764                | 6796                | 6650                |
| <i>Panel B: By Risk</i>       |                     |                     |                     |
| N Wins $\times$ HR            | 0.047<br>(0.088)    | 0.038<br>(0.086)    | 0.130<br>(0.118)    |
| N Wins $\times$ LR            | 0.456***<br>(0.127) | 0.459***<br>(0.155) | 0.672**<br>(0.281)  |
| Dep Var Mean, HR              | .902                | .403                | 17.671              |
| Dep Var Mean, LR              | .145                | .053                | 1.263               |
| Observations                  | 7764                | 6796                | 6650                |
| <i>Panel C: LR, Age 18-22</i> |                     |                     |                     |
| N Wins $\times$ LR            | 0.600***<br>(0.155) | 0.678***<br>(0.183) | 1.026***<br>(0.367) |
| Dep Var Mean, LR              | .097                | .034                | .805                |
| Observations                  | 7390                | 6314                | 6363                |

Notes: Estimated effects of peer wins on intensive margin outcomes using Poisson regression. Panel A reports estimates across the sample, pooling by estimated risk. Each estimate in Panel A is for the effect of the number of lottery applicants from their neighborhood group who won their first choice in the lottery on the arrest or incarceration outcome indicated by the column heading. Neighborhood groups include male students in the same cohort, initially assigned neighborhood school, and CBG. Each regression includes expected wins and CBG fixed effects. Panel B reports the same set of estimates for the high- and low-risk students, based on the estimated probability of arrest.  $N\ Wins \times HR$  shows estimates for the group with higher than median estimated risk, and  $N\ Wins \times LR$  shows estimates for the group with lower than median estimated risk. These are estimated in a single regression using interaction terms. Panel C reports estimates for the low risk group for outcomes measured over ages 18-22. Panel B and C regressions include CBG fixed effects, interaction terms between risk indicators and expected wins, and a risk indicator. Standard errors are clustered at the CBG-Neighborhood School-Cohort level.

Table A7: Days Incarcerated Robustness

|                         | Main              | Poisson            | Topcode<br>OLS    | Topcode<br>Poisson | ln(1+days)           | Arcsin(days)         |
|-------------------------|-------------------|--------------------|-------------------|--------------------|----------------------|----------------------|
| <i>Panel A: Pooled</i>  |                   |                    |                   |                    |                      |                      |
| N Wins                  | 0.951<br>(0.830)  | 0.155<br>(0.111)   | 0.589<br>(0.509)  | 0.116<br>(0.094)   | 0.027<br>(0.017)     | 0.031<br>(0.020)     |
| APE                     |                   | 1.496              |                   | 0.788              |                      |                      |
| Observations            | 8,563             | 6,650              | 8,563             | 6,650              | 8,563                | 8,563                |
| <i>Panel B: By Risk</i> |                   |                    |                   |                    |                      |                      |
| N Wins $\times$ HR      | 1.104<br>(1.522)  | 0.130<br>(0.118)   | 0.504<br>(0.897)  | 0.067<br>(0.101)   | 0.004<br>(0.030)     | 0.004<br>(0.035)     |
| N Wins $\times$ LR      | 0.889*<br>(0.530) | 0.672**<br>(0.281) | 0.720*<br>(0.406) | 0.678**<br>(0.287) | 0.049***<br>(0.0156) | 0.059***<br>(0.0182) |
| Observations            | 8,563             | 6,650              | 8,563             | 6,650              | 8,563                | 8,563                |

Notes: Effects of neighborhood wins on days incarcerated. Column labels refer to the method used for each result: (1) OLS; (2) Poisson regression; (3) and (4) are top coded, replacing the top 1% values of days incarcerated with the 99th percentile (250); (5) OLS using  $\ln(1 + \text{days incarcerated})$  as outcome; and (6) OLS using  $\arcsin(\text{days incarcerated})$  as outcome. Panel A reports estimates are for the full sample of non-applicants. Each estimate in Panel A is for the effect of the number of students from their neighborhood group who won their first choice in the lottery. Neighborhood groups include male students in the same cohort, initially assigned neighborhood school, and CBG. Each estimate is conditional on expected wins and CBG fixed effects. Panel B reports estimates for above and below median risk. Each column in panel B is estimated using interactions between risk indicators and the number of wins and expected wins.

Table A8: Selection of Applicants on Test Scores

|                         | Math                | Reading             | Math                | Reading             |
|-------------------------|---------------------|---------------------|---------------------|---------------------|
| Applicant, Lost Lottery | 0.371***<br>(0.045) | 0.352***<br>(0.040) | 0.080***<br>(0.028) | 0.055**<br>(0.026)  |
| Math EOG 4th            |                     |                     | 0.647***<br>(0.010) | 0.247***<br>(0.010) |
| Read EOG 4th            |                     |                     | 0.161***<br>(0.009) | 0.527***<br>(0.011) |
| Observations            | 18397               | 18331               | 18397               | 18331               |

Notes: Comparison of applicants who lost the lottery and attended their initially assigned neighborhood school with non-applicants who attended their initially assigned neighborhood school. Each column reports estimates from a different regression of math or reading test score on an indicator for being in our lottery sample and losing the first choice in the lottery. Includes observations for up to 3 years post-lottery, i.e., 6th - 8th grade. Estimates in Columns 3 and 4 are conditional on 4th grade reading and math scores, with coefficients reported in the table. Each is also conditional on race/ethnicity, economic disadvantage, whether the student was ever ELL, indicators for missing lagged test scores, and CBG, neighborhood school, cohort fixed effects, and grade of test score. Sample limited to boys only. Standard errors are clustered at the CBG-Neighborhood School-Cohort level.

Table A9: Effect of Winning on Own Arrest Outcomes by Quintile

|                                   | Pr(Arrest)        | Pr(Violent)          | Pr(Incarc.)          | All Arrests          | Violent Arrests     | Days Incarc.          |
|-----------------------------------|-------------------|----------------------|----------------------|----------------------|---------------------|-----------------------|
| <i>Panel A: By Risk Quintiles</i> |                   |                      |                      |                      |                     |                       |
| Q5 (High)                         | -0.115<br>(0.078) | -0.113<br>(0.074)    | -0.173***<br>(0.050) | -1.555***<br>(0.563) | -0.699**<br>(0.321) | -29.497**<br>(14.925) |
| Q4                                | 0.014<br>(0.060)  | 0.028<br>(0.049)     | -0.000<br>(0.047)    | -0.069<br>(0.558)    | -0.007<br>(0.332)   | -11.834<br>(12.619)   |
| Q3                                | 0.027<br>(0.039)  | 0.052*<br>(0.031)    | -0.006<br>(0.029)    | 0.132<br>(0.222)     | 0.075<br>(0.100)    | 4.809<br>(4.250)      |
| Q2                                | -0.031<br>(0.041) | -0.054***<br>(0.020) | -0.041*<br>(0.024)   | -0.161*<br>(0.093)   | -0.065<br>(0.040)   | 1.262<br>(1.954)      |
| Q1 (Low)                          | -0.011<br>(0.022) | -0.024<br>(0.022)    | -0.023<br>(0.016)    | -0.015<br>(0.031)    | -0.027<br>(0.026)   | 0.112<br>(0.328)      |
| Observations                      | 1802              | 1802                 | 1802                 | 1802                 | 1802                | 1802                  |
| <i>Panel B: By Risk</i>           |                   |                      |                      |                      |                     |                       |
| Q5                                | -0.115<br>(0.078) | -0.112<br>(0.074)    | -0.172***<br>(0.050) | -1.572***<br>(0.563) | -0.704**<br>(0.322) | -29.751**<br>(14.915) |
| (Q1-Q4)                           | -0.001<br>(0.022) | -0.000<br>(0.019)    | -0.017<br>(0.017)    | -0.030<br>(0.161)    | -0.007<br>(0.091)   | -1.381<br>(3.444)     |
| Dep Var Mean, Q5                  | .262              | .164                 | .171                 | 1.025                | .465                | 17.156                |
| Dep Var Mean, Q1-Q4               | .084              | .048                 | .043                 | .286                 | .125                | 4.472                 |
| Observations                      | 1802              | 1802                 | 1802                 | 1802                 | 1802                | 1802                  |

Notes: Estimated effect of attending the first choice school on own arrests using winning the first choice in the lottery as an instrument. Each is conditional on the set of student characteristics, group indicators, and the estimated win probability interacted with group indicators. Panel A includes separate estimates for each quintile of predicted arrest risk. Panel B includes a low-risk estimates, which pools quintiles 1-4, and high-risk estimate which includes quintile 5. Both panels are estimated using interaction terms between predicted risk indicators and the treatment. Standard errors are clustered at the application choice by year level.

Table A10: Effect of Peer Wins on Arrest Outcomes by Risk Quintile

|                                  | Pr(Arrest)        | Pr(Violent)       | Pr(Incarc.)        | All Arrests       | Violent Arrests   | Days Incarc.      |
|----------------------------------|-------------------|-------------------|--------------------|-------------------|-------------------|-------------------|
| <i>Panel A: By Risk Quintile</i> |                   |                   |                    |                   |                   |                   |
| Q5 (High)                        | -0.004<br>(0.065) | 0.076<br>(0.062)  | -0.001<br>(0.057)  | 0.305<br>(0.583)  | 0.264<br>(0.244)  | 9.353<br>(12.201) |
| Q4                               | -0.011<br>(0.032) | -0.036<br>(0.027) | -0.031<br>(0.027)  | -0.138<br>(0.209) | -0.109<br>(0.108) | -2.880<br>(5.775) |
| Q3                               | 0.018<br>(0.018)  | 0.008<br>(0.015)  | 0.047**<br>(0.020) | 0.169<br>(0.106)  | 0.073<br>(0.049)  | 4.727<br>(3.074)  |
| Q2                               | 0.023<br>(0.019)  | 0.006<br>(0.011)  | 0.014*<br>(0.007)  | 0.062<br>(0.045)  | 0.007<br>(0.019)  | 0.544<br>(0.710)  |
| Q1 (Low)                         | 0.020*<br>(0.011) | 0.005<br>(0.006)  | 0.013*<br>(0.008)  | 0.059<br>(0.042)  | 0.015<br>(0.018)  | -0.136<br>(0.459) |
| Observations                     | 8563              | 8563              | 8563               | 8563              | 8563              | 8563              |
| <i>Panel B: By Risk</i>          |                   |                   |                    |                   |                   |                   |
| Q5                               | -0.000<br>(0.065) | 0.079<br>(0.062)  | 0.002<br>(0.057)   | 0.318<br>(0.584)  | 0.272<br>(0.246)  | 9.211<br>(12.253) |
| (Q1-Q4)                          | 0.013<br>(0.008)  | -0.003<br>(0.006) | 0.011*<br>(0.006)  | 0.043<br>(0.045)  | 0.000<br>(0.020)  | 0.559<br>(1.007)  |
| Dep Var Mean, HR                 | .314              | .23               | .224               | 1.463             | .625              | 28.051            |
| Dep Var Mean, LR                 | .082              | .039              | .038               | .241              | .088              | 3.19              |
| Observations                     | 8563              | 8563              | 8563               | 8563              | 8563              | 8563              |

Notes: Estimated effect of peer exits on outcomes. Number of peer wins in the lottery is used as an instrument for exits. Each is conditional on expected wins interacted with group indicators, group indicators, and CBG fixed effects. Panel A includes separate estimates for each quintile of predicted arrest risk. Panel B includes a low-risk estimate, which pools quintiles 1-4, and high-risk estimate which includes quintile 5. Both panels are estimated using interaction terms between predicted risk indicators and the treatment. Standard errors are clustered at the CBG-Neighborhood School-Cohort level.

Table A11: Peer Effects on Test Scores and Graduation

|                                     | Math               | Reading            | On Time<br>Grad.  | Dropout           |
|-------------------------------------|--------------------|--------------------|-------------------|-------------------|
| <i>Panel A: Pooled</i>              |                    |                    |                   |                   |
| N Exit                              | -0.023<br>(0.015)  | -0.028*<br>(0.017) | -0.002<br>(0.010) | 0.009<br>(0.009)  |
| Observations                        | 21875              | 21798              | 5936              | 5936              |
| <i>Panel B: Effect Win, by Risk</i> |                    |                    |                   |                   |
| N Exit X HR                         | -0.009<br>(0.033)  | -0.023<br>(0.036)  | -0.014<br>(0.035) | 0.035<br>(0.028)  |
| N Exit X LR                         | -0.034*<br>(0.017) | -0.034*<br>(0.018) | 0.002<br>(0.011)  | -0.000<br>(0.008) |
| Observations                        | 21875              | 21798              | 5936              | 5936              |

Notes: Estimated effect of peer exits on non-applicant outcomes. Each is conditional expected wins and CBG fixed effects. Panel A includes estimates from the full sample. Panel B reports the same set of estimates for the high- and low-risk students, based on the estimated probability of arrest.  $N\ Exit \times HR$  shows estimates for the group with higher than median estimated risk, and  $N\ Exit \times LR$  shows estimates for the group with lower than median estimated risk. Panel B is estimated using interaction terms between win proportion and high- and low-risk. Panel B regressions also include interaction terms between risk indicators and expected wins, as well as a risk indicator. Test score results include up to three years post-lottery, grades 6-8 for most individuals. The last two columns show outcomes related to graduation and dropout. *On Time Grad.* is an indicator for graduating within 7 years post lottery (12th grade year for on-time progression). *Dropout* is an indicator equal to one if the student was ever observed as dropping out in the 7 years post lottery. The last two columns only include students who were observed graduating or dropping out in the NC data. These include up to one observation per student. Standard errors are clustered at the CBG-Neighborhood School-Cohort level.

Table A12: Heterogeneity in Peer Effects

|                                                   | Pr(Arrest)        | Pr(Violent)       | Pr(Incarc.)        | All Arrests       | Violent Arrests   | Days Incarc.      |
|---------------------------------------------------|-------------------|-------------------|--------------------|-------------------|-------------------|-------------------|
| <i>Panel A: Heterogeneity by Race / Ethnicity</i> |                   |                   |                    |                   |                   |                   |
| N Exit × White                                    | 0.025*<br>(0.014) | 0.013<br>(0.008)  | 0.020**<br>(0.010) | 0.138*<br>(0.071) | 0.053*<br>(0.028) | 1.305<br>(1.027)  |
| N Exit × Black                                    | 0.002<br>(0.018)  | 0.003<br>(0.016)  | 0.005<br>(0.015)   | 0.033<br>(0.133)  | 0.014<br>(0.056)  | 1.890<br>(2.942)  |
| N Exit × Hispanic                                 | 0.000<br>(0.029)  | -0.018<br>(0.024) | 0.008<br>(0.020)   | -0.035<br>(0.132) | -0.030<br>(0.064) | 1.792<br>(4.315)  |
| N Exit × Other                                    | 0.026<br>(0.026)  | -0.004<br>(0.018) | 0.011<br>(0.021)   | 0.046<br>(0.145)  | 0.010<br>(0.068)  | -2.289<br>(4.115) |
| N                                                 | 8563              | 8563              | 8563               | 8563              | 8563              | 8563              |
| <i>Panel B: Heterogeneity by Test Scores</i>      |                   |                   |                    |                   |                   |                   |
| Above Median                                      | 0.027*<br>(0.015) | 0.002<br>(0.009)  | 0.009<br>(0.010)   | 0.005<br>(0.081)  | -0.030<br>(0.046) | -1.922<br>(2.208) |
| Below Median                                      | -0.000<br>(0.014) | 0.008<br>(0.014)  | 0.014<br>(0.012)   | 0.116<br>(0.113)  | 0.072<br>(0.057)  | 3.209<br>(2.686)  |
| Dep Var Mean, High                                | .065              | .027              | .027               | .191              | .061              | 2.162             |
| Dep Var Mean, Low                                 | .183              | .118              | .119               | .746              | .309              | 13.424            |
| Observations                                      | 8563              | 8563              | 8563               | 8563              | 8563              | 8563              |

Notes: Heterogeneity in estimated effects of the peer exits on outcomes. The interactions between group indicators and the number of peer wins are used as instruments for the exit variables. Panel A reports estimates by race / ethnicity and Panel B reports estimates by whether the average of the student's 4th grade math and reading test scores was above or below the median. Each column in each panel reports estimates from a single regression using interactions. Each cell reports a group-specific estimate for the effect of peer applicant exits from their neighborhood group on the arrest or incarceration outcome indicated by the column heading. Each estimate is conditional on interactions between expected wins and group indicators, group indicators, and CBG fixed effects. Standard errors are clustered at the CBG-Neighborhood School-Cohort level.

Table A13: Effect of Peer Exits on Arrest Outcomes (Girls)

|                                        | Pr(Arrest)        | Pr(Violent)        | Pr(Incarc.)       | All Arrests       | Violent Arrests  | Days Incarc.      |
|----------------------------------------|-------------------|--------------------|-------------------|-------------------|------------------|-------------------|
| <i>Panel A: Pooled</i>                 |                   |                    |                   |                   |                  |                   |
| N Exit                                 | 0.003<br>(0.008)  | 0.012**<br>(0.006) | 0.002<br>(0.005)  | 0.000<br>(0.022)  | 0.018<br>(0.013) | -0.117<br>(0.210) |
| Observations                           | 7985              | 7985               | 7985              | 7985              | 7985             | 7985              |
| <i>Panel B: With controls, By Risk</i> |                   |                    |                   |                   |                  |                   |
| N Exit $\times$ HR                     | -0.010<br>(0.015) | 0.015<br>(0.012)   | -0.000<br>(0.010) | 0.001<br>(0.048)  | 0.020<br>(0.026) | 0.021<br>(0.387)  |
| N Exit $\times$ LR                     | 0.014<br>(0.011)  | 0.006<br>(0.006)   | 0.003<br>(0.005)  | -0.005<br>(0.020) | 0.012<br>(0.011) | -0.242<br>(0.311) |
| Dep Var Mean, HR                       | .103              | .054               | .041              | .221              | .098             | 1.001             |
| Dep Var Mean, LR                       | .019              | .006               | .005              | .042              | .013             | .313              |
| Observations                           | 7985              | 7985               | 7985              | 7985              | 7985             | 7985              |

Notes: Estimated effects of peer exits on outcomes in the sample of girls. Panel A reports estimates for the full sample. Each estimate in Panel A is for the effect of the number of applicants from their neighborhood group who attend a different school than their initially assigned neighborhood school in the year after the lottery on the arrest or incarceration outcome indicated by the column heading. The number of peer applicants who win their first choice in the lottery is used as an instrument for peer exits. Neighborhood groups include female students in the same cohort, initially assigned neighborhood school, and CBG. Each estimate is conditional on expected wins, school-cohort fixed effects, and group level lottery controls. Panel B reports the same set of estimates for the high- and low-risk students, based on the estimated probability of arrest. *N Exit  $\times$  HR* shows estimates for the group with higher than median estimated risk, and *N Exit  $\times$  LR* shows estimates for the group with lower than median estimated risk. These are estimated in a single regression using interaction terms. Panel B regressions also include interaction terms between risk indicators and expected wins, interactions between risk indicators and group level lottery controls, and a risk indicator. Standard errors are clustered at the CBG-Neighborhood School-Cohort level.

Table A14: Effects of Same CBG-School-Cohort Girl Wins on Boy Outcomes

|                            | Pr(Arrest)       | Pr(Violent)       | Pr(Incarc.)      | All Arrests      | Violent Arrests  | Days Incarc.      |
|----------------------------|------------------|-------------------|------------------|------------------|------------------|-------------------|
| <i>Panel A: Pooled</i>     |                  |                   |                  |                  |                  |                   |
| N Exits, Girls             | 0.003<br>(0.009) | 0.005<br>(0.007)  | 0.009<br>(0.008) | 0.046<br>(0.057) | 0.027<br>(0.023) | -0.255<br>(1.485) |
| Observations               | 8127             | 8127              | 8127             | 8127             | 8127             | 8127              |
| <i>Panel B: By Risk</i>    |                  |                   |                  |                  |                  |                   |
| N Exits, Girls $\times$ HR | 0.009<br>(0.016) | 0.014<br>(0.014)  | 0.021<br>(0.014) | 0.112<br>(0.102) | 0.055<br>(0.040) | 0.216<br>(2.714)  |
| N Exits, Girls $\times$ LR | 0.000<br>(0.011) | -0.001<br>(0.007) | 0.002<br>(0.008) | 0.018<br>(0.048) | 0.009<br>(0.020) | 0.242<br>(0.874)  |
| Dep Var Mean, HR           | .203             | .131              | .129             | .834             | .346             | 15.208            |
| Dep Var Mean, LR           | .053             | .021              | .02              | .125             | .038             | .865              |
| Observations               | 8127             | 8127              | 8127             | 8127             | 8127             | 8127              |

Notes: Estimated effects of wins among same School-CBG-Cohort girls on outcomes in the sample of boys. Panel A reports estimates for the full sample. Each estimate in Panel A is for the effect of same-neighborhood girls who won their first choice in the lottery on the arrest or incarceration outcome indicated by the column heading. Neighborhood groups include students in the same cohort, initially assigned neighborhood school, and CBG. Each estimate is conditional on wins among boys in the same peer group, expected wins for boys and girls, and school-cohort fixed effects, and group level lottery controls. Panel B reports the same set of estimates for the high- and low-risk students, based on the estimated probability of arrest. (*N Wins, Girls  $\times$  HR* shows estimates for the group with higher than median estimated risk, and *N Wins, Girls  $\times$  LR* shows estimates for the group with lower than median estimated risk. These are estimated in a single regression using interaction terms. Panel B regressions also include interaction terms between risk indicators and expected wins, interactions between risk indicators and group level lottery controls, and a risk indicator. Standard errors are clustered at the CBG-Neighborhood School-Cohort level.

Table A15: Estimates by Group Size (Split within Risk Type)

|                                        | Pr(Arrest)         | Pr(Violent)       | Pr(Incarc.)        | All Arrests        | Violent Arrests    | Days Incarc.      |
|----------------------------------------|--------------------|-------------------|--------------------|--------------------|--------------------|-------------------|
| <i>Panel A: Pooled</i>                 |                    |                   |                    |                    |                    |                   |
| N Exit $\times$ Large N                | 0.004<br>(0.007)   | -0.005<br>(0.006) | 0.007<br>(0.006)   | 0.014<br>(0.055)   | -0.008<br>(0.022)  | 0.504<br>(1.118)  |
| N Exit $\times$ Small N                | 0.079<br>(0.050)   | 0.068*<br>(0.037) | 0.038<br>(0.033)   | 0.516*<br>(0.288)  | 0.260**<br>(0.122) | 6.860<br>(5.186)  |
| Dep Var Mean, Large N                  | .115               | .064              | .062               | .39                | .155               | 5.912             |
| Dep Var Mean, Small N                  | .13                | .081              | .081               | .524               | .211               | 9.27              |
| Observations                           | 8563               | 8563              | 8563               | 8563               | 8563               | 8563              |
| <i>Panel B: By Group Size and Risk</i> |                    |                   |                    |                    |                    |                   |
| Large N $\times$ HR                    | -0.021<br>(0.021)  | -0.020<br>(0.018) | -0.015<br>(0.020)  | -0.124<br>(0.166)  | -0.071<br>(0.072)  | 0.680<br>(3.649)  |
| Large N $\times$ LR                    | 0.016**<br>(0.008) | 0.003<br>(0.005)  | 0.018**<br>(0.007) | 0.074**<br>(0.035) | 0.021<br>(0.014)   | 0.513<br>(0.491)  |
| Small N $\times$ HR                    | 0.073<br>(0.079)   | 0.093<br>(0.066)  | 0.039<br>(0.058)   | 0.856<br>(0.545)   | 0.445*<br>(0.230)  | 9.736<br>(10.151) |
| Small N $\times$ LR                    | 0.098*<br>(0.054)  | 0.054<br>(0.036)  | 0.049<br>(0.034)   | 0.243<br>(0.213)   | 0.111<br>(0.087)   | 4.934<br>(4.415)  |
| Mean, Large N, HR                      | .186               | .116              | .113               | .707               | .296               | 12.181            |
| Mean, Large N, LR                      | .057               | .022              | .019               | .13                | .039               | .782              |
| Mean, Small N, HR                      | .232               | .157              | .157               | 1.024              | .425               | 19.6              |
| Mean, Small N, LR                      | .048               | .02               | .02                | .121               | .038               | .963              |
| Observations                           | 8563               | 8563              | 8563               | 8563               | 8563               | 8563              |

Notes: Estimated effects of the peer exits in large vs. small neighborhood groups. *Large N* refers to those in groups that are larger than the median size within risk type, and *Small N* refers to those groups that are smaller than median size within risk type. Panel A reports estimates by group size, pooling by estimated risk. Each estimate in Panel A is for the effect of exits of applicants from their neighborhood group on the arrest or incarceration outcome indicated by the column heading. Neighborhood groups include male students in the same cohort, initially assigned neighborhood school, and CBG. Each estimate is conditional on the group size indicator and CBG fixed effects. Panel B reports the same set of estimates for the high- and low-risk students, based on the estimated probability of arrest. Rows with  $\times$  *HR* show estimates for the group with higher than median estimated risk, and rows with  $\times$  *LR* show estimates for the group with lower than median estimated risk. These are estimated in a single regression using interaction terms. Panel B regressions also include interaction terms between group indicators and expected wins, as well as group indicators. Standard errors are clustered at the CBG-Neighborhood School-Cohort level.

Table A16: Effect of Peer Wins Interacted with Elementary School Proxy

|                                                                        | Pr(Arrest)         | Pr(Violent)       | Pr(Incarc.)         | All Arrests        | Violent Arrests    | Days Incarc.       |
|------------------------------------------------------------------------|--------------------|-------------------|---------------------|--------------------|--------------------|--------------------|
| <i>Panel A: Interaction with Mean of Winners from Same Elem School</i> |                    |                   |                     |                    |                    |                    |
| N Wins $\times$ HR                                                     | -0.003<br>(0.012)  | -0.002<br>(0.010) | 0.002<br>(0.010)    | -0.020<br>(0.091)  | -0.010<br>(0.036)  | 0.446<br>(2.192)   |
| $\times$ Mn(SameElem.)                                                 | 0.007<br>(0.021)   | 0.005<br>(0.017)  | -0.009<br>(0.017)   | 0.141<br>(0.129)   | 0.066<br>(0.061)   | 1.808<br>(3.579)   |
| N Wins $\times$ LR                                                     | 0.015*<br>(0.008)  | 0.007<br>(0.006)  | 0.021***<br>(0.006) | 0.100**<br>(0.044) | 0.036**<br>(0.018) | 1.571**<br>(0.738) |
| $\times$ Mn(SameElem.)                                                 | 0.010<br>(0.011)   | -0.003<br>(0.007) | -0.009<br>(0.008)   | -0.056<br>(0.049)  | -0.028<br>(0.020)  | -1.574*<br>(0.803) |
| Observations                                                           | 8563               | 8563              | 8563                | 8563               | 8563               | 8563               |
| <i>Panel B: School-CBG-Cohort Fixed Effects</i>                        |                    |                   |                     |                    |                    |                    |
| N Wins                                                                 |                    |                   |                     |                    |                    |                    |
| $\times$ HR $\times$ Mn(SameElem.)                                     | 0.000<br>(0.024)   | -0.011<br>(0.020) | -0.025<br>(0.020)   | -0.010<br>(0.114)  | -0.003<br>(0.056)  | -0.386<br>(3.833)  |
| $\times$ LR $\times$ Mn(SameElem.)                                     | 0.034**<br>(0.014) | 0.001<br>(0.012)  | -0.000<br>(0.011)   | 0.004<br>(0.067)   | 0.002<br>(0.029)   | 0.627<br>(2.058)   |
| Observations                                                           | 8417               | 8417              | 8417                | 8417               | 8417               | 8417               |

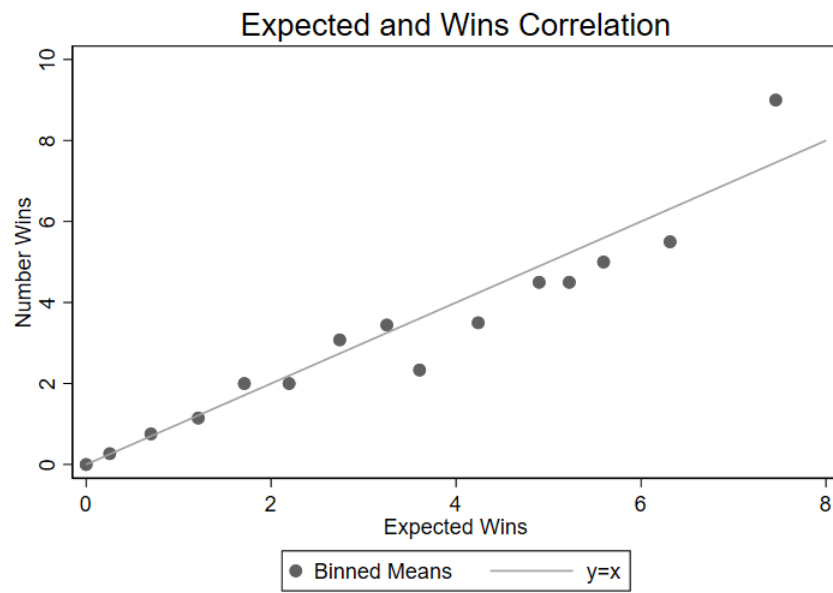
Notes: Estimated effect of wins on outcomes including interaction terms with the mean of winners from the same elementary school. Panel A includes the main effect, wins interacted with high- or low-risk, and two additional interaction terms. The interactions  $\times Mn(\text{Same Elem.})$  include wins from the group that the focal student attended school with in 5th grade. Panel A conditions on expected wins and CBG fixed effects. Panel B also includes school by cohort fixed effects. Panel C includes cohort by school by CBG fixed effects (rather than cohort, CBG, and School fixed effects separately), and separate estimates of interactions between wins and the fraction of winners who attended the same school in 5th grade for high- and low-risk non-applicants. Standard errors are clustered at the CBG-Neighborhood School-Cohort level.

Table A17: Estimates with Same Race/Ethnicity Interactions

|                                                                              | Pr(Arrest)        | Pr(Violent)       | Pr(Incarc.)        | All Arrests        | Violent Arrests   | Days Incarc.        |
|------------------------------------------------------------------------------|-------------------|-------------------|--------------------|--------------------|-------------------|---------------------|
| <i>Panel A: Pooled</i>                                                       |                   |                   |                    |                    |                   |                     |
| N Exit                                                                       | 0.016<br>(0.014)  | 0.005<br>(0.012)  | 0.011<br>(0.011)   | 0.174*<br>(0.104)  | 0.031<br>(0.038)  | 4.366<br>(2.735)    |
| N Exit Same Race                                                             | -0.005<br>(0.019) | -0.001<br>(0.015) | 0.000<br>(0.015)   | -0.189<br>(0.136)  | -0.013<br>(0.049) | -5.581<br>(4.054)   |
| Observations                                                                 | 8563              | 8563              | 8563               | 8563               | 8563              | 8563                |
| <i>Panel B: With Same Race/Ethnicity Interactions, by Non-Applicant Risk</i> |                   |                   |                    |                    |                   |                     |
| N Exit $\times$ HR                                                           | -0.024<br>(0.035) | -0.007<br>(0.026) | -0.035<br>(0.035)  | 0.263<br>(0.243)   | 0.003<br>(0.089)  | 10.794<br>(8.222)   |
| Same Race Exits $\times$ HR                                                  | 0.040<br>(0.055)  | 0.016<br>(0.043)  | 0.062<br>(0.052)   | -0.404<br>(0.401)  | 0.044<br>(0.149)  | -16.125<br>(14.018) |
| N Exit $\times$ LR                                                           | 0.029*<br>(0.016) | 0.007<br>(0.011)  | 0.028**<br>(0.012) | 0.138**<br>(0.064) | 0.035<br>(0.030)  | 1.650<br>(1.140)    |
| Same Race Exits $\times$ LR                                                  | -0.012<br>(0.016) | -0.000<br>(0.011) | -0.017<br>(0.011)  | -0.081<br>(0.065)  | -0.017<br>(0.033) | -0.788<br>(1.081)   |
| Observations                                                                 | 8563              | 8563              | 8563               | 8563               | 8563              | 8563                |

Notes: Estimated effects of the peer exits on outcomes and additional effect from alternate peer groups defined at the school-cohort-CBG-race/ethnicity level. IV estimates using number of peer wins as instrument. Panel A reports estimates across the sample, pooling by estimated risk. Each column in Panel A includes an estimate for the effect of applicant exits on the arrest or incarceration outcome indicated by the column heading, and another estimate for the proportion of students from their school-CBG-cohort-race/ethnicity group who won their first choice in the lottery. These are estimated in one regression. Each estimate is conditional on expected wins in each group and CBG fixed effects. Panel B reports the same set of estimates for the high- and low-risk students, based on the estimated probability of arrest. *N Exit  $\times$  HR* shows main estimates for the group with higher than median estimated risk, and *N Exit  $\times$  LR* shows estimates for the group with lower than median estimated risk. Each column in Panel B is estimated in a single regression using interaction terms. In Panel B, we also include interaction terms between risk indicators expected wins variables. Standard errors are clustered at the CBG-Neighborhood School-Cohort level.

Figure A1: Correlations Wins and Expected Wins



Notes: Binned averages of wins and expected wins with the line for  $y=x$ . 46% of the groups have expected wins = 0, i.e., not exposed. 98% have expected wins less than 3.

# Appendix B

## Estimating Lottery Win Probabilities and Expected Wins

We start with the sample of students who submitted at least one choice in the lottery over our sample period. The lottery proceeds in three rounds. In the first round, only the first choices of the applicants are considered. We focus on the first-round applications in our main analysis that meet the following criteria:

1. Submitted at least one choice in the lottery.
2. Their first choice was to a program that is not in their designated home school.
3. Their first-choice program did not include subjective criteria in the admission process.<sup>1</sup>
4. They did not receive a sibling placement, or other apparent magnet continuation placement.<sup>2</sup>

The resulting sample includes students for whom winning the lottery means that they will be assigned to a different school than their residentially zoned school based on their residence at the time of the lottery for 6th grade admissions, which takes place during their 5th grade school year. In some cases, students may apply to a program within their neighborhood school, but those applicants do not meet criteria (2), so they are not included in our main sample.

We group applicants based on application choice, year of application, and observable lottery criteria which include whether the student's neighborhood school or magnet continuation school is a Title I choice school (0 or 1), whether the student is economically disadvantaged (0 or 1), and whether the student was at grade level in reading on the fourth-grade standardized reading exam (0, 1, or missing). We construct the predicted win probabilities,  $\hat{P}_{ibst}$ , using the proportion of applicants within the application choice, year, Title I School Status, economic disadvantage status, and reading level groups who won the first choice in the lottery. The lottery sample includes the set of students with  $\hat{P}_{ibst}$  between zero and one who also met the entrance requirements for their first-choice program. We use the predicted wins to construct expected wins by summing win probabilities within CBG-School-Cohort to obtain an expected number of wins.

## Constructing Group Level Lottery-Related Controls

The focal students in this analysis are non-applicants who have a win probability of zero. The students who contribute to the expected wins are lottery applicants who meet the lottery sample criteria. The sample generating the expected wins and the estimation sample are distinct. In addition, students who specify a lottery choice, but do not meet the criteria outlined above, do not contribute to either sample. Effectively, we can view their assignments

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<sup>1</sup>Arts programs require an audition and leadership programs which require an interview. Both include admission criteria that are subjective and not observable.

<sup>2</sup>We filter out applicants that likely receive automatic placements which is inferred from the data and CMS documentation.

as non-random, and they would not contribute to identification. However, we do use this subsample to construct some of the lottery-specific conditioning variables (used in Table 7). These additional conditioning variables account for sibling slots, non-first choices, and other applicants not meeting the criteria for random lottery assignment, which may impact student expectations regarding lottery win probabilities and peer movement. However, conditioning on these additional lottery-related outcomes is inconsequential to our results (see Panel C of Table 7).

The additional lottery-specific conditioning variables are:

1. *Number of students who won their second or third choice in the lottery*

The number of students who won their second or third choice in the lottery is constructed using the same sample of lottery applicants in oversubscribed lotteries who did not receive automatic placements and met the stated requirements for their program of application. We construct the total number of students in the group who won their second or third choice as the sum of an indicator for winning the second or third choice within the CBG-School-Cohort group.

2. *Number of other students submitting lottery applications*

As outlined in the previous section, we limit the lottery applicant sample to those who met several criteria, i.e., they are in an oversubscribed lottery and there is some random assignment that can be used for estimation. The remaining lottery applicants, e.g., who receive a sibling placement or apply to an undersubscribed lottery, are not used in either of the estimation samples. We construct two conditioning variables from this sample, the first of which is the number of applicants in the CBG-School-Cohort group who do not meet the criteria for the estimation sample.

3. *Number of other students assigned to their lottery choice*

Using the same set of students who applied but did not meet the criteria for the lottery estimation sample, we construct a variable for the number of applicants who were assigned to their lottery choice. This would include, for example, students who received sibling placements, lottery winners who applied to arts or leadership programs, or applicants to undersubscribed lotteries.

## **Estimating Arrest Risk**

We start with the full sample of students in the district from the three cohorts that we use (Column 1 of Table 1). We predict the probability of arrest conditional on a set of individual characteristics, as well as school and CBG level means. The dependent variable is an indicator for any arrest from ages 16 to 22. The explanatory variables are indicators for race/ethnicity, economic disadvantage, 4th grade math and reading scores, dummy variables for missing test scores, age, a dummy for missing age, CBG level means of each race/ethnicity indicator, economic disadvantage, math and reading test scores, and school attendance zone level means of each race/ethnicity indicator, economic disadvantage, math and reading test scores. We also include individual indicators for lottery applicants (based on our lottery sample definition) and those who won their first choice in the lottery, as well as group level

measures for the number of peer applicants and the number of peer lottery winners. We estimate the parameters using logistic regression and predict the individual probability of arrest,  $\hat{R}_{ibst}$ , omitting the contributions from the indicator for winning the lottery and the measure for the number of peer lottery winners. In our main heterogeneity analyses, e.g., Panel B of Table 3, we split the sample into groups with high and low arrest risk using the sample median  $\hat{R}_{ibst}$  to create risk indicators.

Table B1: Arrest Prediction

|                          | Boys                   | Girls                  |
|--------------------------|------------------------|------------------------|
| Applicant                | -0.120<br>(0.103)      | -0.279*<br>(0.146)     |
| Won First Choice         | -0.181<br>(0.174)      | -0.0902<br>(0.246)     |
| N of Peer Applicants     | -0.0366**<br>(0.0178)  | 0.00183<br>(0.0217)    |
| N of Peer Wins           | 0.0434<br>(0.0363)     | -0.0131<br>(0.0466)    |
| White                    | -0.0159<br>(0.137)     | -0.235<br>(0.194)      |
| Black                    | 0.590***<br>(0.120)    | 0.381**<br>(0.160)     |
| Hispanic                 | -0.225<br>(0.140)      | -0.951***<br>(0.208)   |
| Ec. Disadvantage         | 0.669***<br>(0.0750)   | 0.804***<br>(0.112)    |
| Math EOG, 4              | -0.213***<br>(0.0435)  | -0.142**<br>(0.0628)   |
| Read EOG, 4              | -0.0909**<br>(0.0420)  | -0.180***<br>(0.0614)  |
| Math Missing, 4          | -0.436<br>(0.267)      | 0.393<br>(0.742)       |
| Read Missing, 4          | 0.281<br>(0.257)       | -0.638<br>(0.736)      |
| Age                      | 0.0246***<br>(0.00434) | 0.0235***<br>(0.00648) |
| Age Missing = 1          | -0.177<br>(0.213)      | 0.335<br>(0.324)       |
| <i>Nbhd School Means</i> |                        |                        |
| White                    | 0.00705<br>(1.445)     | -0.542<br>(2.160)      |
| Black                    | -0.498<br>(1.487)      | -0.658<br>(2.161)      |
| Hispanic                 | -0.813<br>(1.615)      | -0.278<br>(2.354)      |
| Ec. Disad.               | 0.715<br>(0.513)       | -0.0135<br>(0.786)     |
| Math, 4                  | 1.205*<br>(0.730)      | 1.397<br>(1.301)       |
| Read, 4                  | -1.292*<br>(0.779)     | -1.512<br>(1.514)      |
| <i>CBG Means</i>         |                        |                        |
| White                    | 0.670<br>(0.665)       | 1.048<br>(0.994)       |
| Black                    | 1.199**<br>(0.596)     | 1.021<br>(0.899)       |
| Hispanic                 | 0.663<br>(0.674)       | 0.965<br>(1.008)       |
| Ec. Disad.               | 0.433<br>(0.361)       | 0.299<br>(0.525)       |
| Math, 4                  | 0.670**<br>(0.319)     | -0.844*<br>(0.473)     |
| Read, 4                  | -0.502<br>(0.333)      | 0.383<br>(0.479)       |
| Observations             | 13,491                 | 13,039                 |

Notes: Arrest prediction estimates from logistic regression with indicator for any arrest age 16-22.

# Appendix C

## Consistency using the Recentered Treatment Variable

To be consistent with the main specification in Borusyak and Hull (2023), we focus on recentering rather than condition on the expected value in this subsection. Specifically, we define the recentered treatment shock, number of applicant wins  $W_{bst}$ , experienced by non-applicants  $j$  for a given CBG ( $b$ )-School ( $s$ )-Cohort ( $t$ ) as

$$\tilde{W}_{bst} = W_{bst} - E[W_{bst}|\Theta_{bst}] \quad (1)$$

where  $W_{bst}$  is the number of wins among male applicants in CBG  $b$ , neighborhood school attendance zone  $s$  and cohort  $t$ , and  $\Theta_{bst}$  is a vector of the lottery schools and priority groups of all applicants.

The model of non-applicant outcomes ( $y_{jbst}$ ) using the recentered treatment as an instrument for applicant departures  $T_{bst}$  is

$$T_{bst} = \gamma_1 \tilde{W}_{bst} + \mu_{bst} \quad (2)$$

$$y_{jbst} = \beta_1 T_{bst} + \epsilon_{jbst}. \quad (3)$$

While recentering assures that

$$E \left[ \frac{1}{N} \sum_{j=1}^N \tilde{W}_{bst} \epsilon_{jbst} \right] = 0, \quad (4)$$

$$Var \left[ \frac{1}{N} \sum_{j=1}^N \tilde{W}_{bst} \epsilon_{jbst} \right] = \frac{1}{N^2} \sum_{j,k} E[(\tilde{W}_{bst})_j (\tilde{W}_{bst})_k (\epsilon_{jbst})_j (\epsilon_{jbst})_k] \quad (5)$$

where the subscript pair  $j, k$  implies all permutations of non-applicant pairs and the subscripts on  $\tilde{W}_{bst}$  identify the recentered treatment variable associated with the cluster to which individual  $j$  or  $k$  belongs, respectively.

Notably, this variance expression may not converge to zero as the sample becomes large, because of correlations between observations in either  $\tilde{X}_{bst}$  or in  $\mu_{ibst}$ . In Proposition S2, Borusyak and Hull (2023) show that the above expression converges to zero if

$$E \left[ \frac{1}{N^2} \sum_{j,k} Cov \left[ (\tilde{W}_{bst})_j (\tilde{W}_{bst})_k | (\Theta_{bst})_j, (\Theta_{bst})_k \right] \right] \rightarrow 0. \quad (6)$$

To obtain asymptotic consistency, we assume that the number of clusters,  $L$  (groups in CBG, school, and cohort,  $bst$ ), grows more slowly than the sample size,  $N$ , and divide the expression into two parts: pairs of observations that belong to the same cluster,  $l$ , and observations that do not.

$$\begin{aligned}
E \left[ \frac{1}{N^2} \sum_{j,k} Cov \left[ (\tilde{W}_{bst})_j (\tilde{W}_{bst})_k | (\Theta_{bst})_j, (\Theta_{bst})_k \right] \right] &= E \left[ \frac{1}{N} \sum_{j=1}^L \frac{N_l}{N} Var \left[ (\tilde{W}_{bst})_j | (\Theta_{bst})_j \right] \right] + \\
&E \left[ \frac{1}{N^2} \sum_{j \in n_l, k \in n_m, l \neq m} Cov \left[ (\tilde{W}_{bst})_j (\tilde{W}_{bst})_k | (\Theta_{bst})_j, (\Theta_{bst})_k \right] \right].
\end{aligned} \tag{7}$$

where  $N_l$  is the number of observations within cluster,  $l$ , and  $n_l$  represents the set of observations in the cluster.

For the first expression, the cluster covariance contributions, the variance of  $\tilde{X}_{bst}$  is finite by inspection. Further, the within-summation weights are equal to the ratio of cluster size to sample size, i.e.,  $\frac{N_l}{N}$ , so the weights sum to one, when summing over the number of clusters. Therefore, the summation in the first expression is finite, and converges to zero with increasing  $N$ .

The second expression, across cluster covariances, is zero based on the equal treatment of equals aspect of lottery randomization. Because the random vector of draws for a given cluster are orthogonal to the random vector of draws for any other cluster, the recentered treatment variables are orthogonal across clusters. This conclusion follows from the more general proof of Lemma S2(ii) in Borusyak and Hull (2023) that the covariance condition is satisfied if the portion of the sample for which the random shocks are correlated grows more slowly than the sample size.

## The Effect of Aggregation on First and Second Stage Estimates

The purpose of this section is to illustrate how the first stage estimates can be unstable to the inclusion of high dimensional fixed effects, even though the risk control assures conditional orthogonality to the error in the outcome equation, and empirically the treatment shock conditional on the risk control passes balance on observables.

We start with a relatively general IV model where the aggregate treatment shock  $W_{lo}$  and endogenous treatment  $T_{lo}$  is the result of many individuals  $i$  experiencing and responding to an exogenous treatment shock,  $w_{ilo}$  and  $t_{ilo}$  in location  $l$  that belongs to a larger cluster  $o$ . In our application,  $i$  represents lottery applicants, the treatment shock  $w_{ilo}$  is winning the lottery, individual treatment or take-up  $t_{ilo}$  is not attending the initially assigned neighborhood school,  $l$  represents block group by attendance zone by cohort clusters, and  $o$  could represent a broader neighborhood, like block group, or a broader group of cohort applicants such as across the entire attendance zone.

We specify aggregate treatment shock  $W_{lo}$  and treatment  $T_{lo}$  as simply the sum (or potentially the mean) of the individual treatment shocks  $w_{ilo}$  and treatment take-up decisions  $t_{ilo}$  where  $\gamma_1$  defines the linear relationship between the individual shock and treatment. The standard Abdulkadiroğlu et al. (2017) (AEA) and Borusyak and Hull (2023) (BH) approach to handling endogeneity of the aggregate treatment shock is add a linear control for the expectation of the shock. However, to allow for spillover effects of treatment shocks across individuals, we also assume that aggregate treatment in  $lo$  is affected by a general function

$f_{lo}$  of shocks that correlate with the clusters  $o$ , either non-linear functions of the individual treatment shocks within  $lo$  or even functions of a broader set of treatment shocks in  $o$ .

$$T_{lo} = \gamma_1 W_{lo} + \gamma_2 E[W_{lo}] + f_{lo}(\Omega_W) + \mu_{lo}$$

Where, in general,  $\Omega_W$  can contain all treatment shocks in  $o$  for any  $lo$ .  $f_{lo}$  will also be correlated with  $T_{lo}$  even after conditioning on  $E[W_{lo}]$  because  $f_{lo}$  contains the actual individual treatment shocks (both the random and systematic components) in  $lo$ . With finite observations in  $l$  and finite groups  $l$  in cluster  $o$ , the random component of the treatment shocks cannot be assumed away asymptotically.

We assume that the moment condition in BH for the IV estimates on the second stage error  $\epsilon_{jk}$  is satisfied, and we specify the a model for aggregate outcomes  $Y_{lo}$  as

$$Y_{lo} = \beta_1 T_{lo} + \beta_2 E[W_{lo}] + \epsilon_{lo}$$

The first stage will deviate from the direct effect of the treatment shock experienced by an individual on their treatment take-up,  $\gamma_1$ , because the function  $f_{lo}$  is embedded in the error and the expectation of this function depends upon  $W_{lo}$ . For convenience, we will refer to this deviation as “bias.”

$$E[f_{lo}(\Omega_W)|W_{lo}, E[W_{lo}]] = \phi_1 W_{lo} + \phi_2 E[W_{lo}]$$

Such that  $\phi_1$  enters as an additive bias in the estimate on  $W_{lo}$  in the equation for treatment take-up.

We write the expectation of the reduced form model by replacing  $T_{lo}$  with the first stage equation in the model for  $Y_{lo}$ . Taking the conditional expectation, we find that

$$E[Y_{lo}|W_{lo}, E[W_{lo}]] = \beta_1(\gamma_1 + \phi_1)T_{lo} + (\beta_2 + \beta_1(\gamma_2 + \phi_2))E[W_{lo}]$$

The first thing to realize is that given the assumption on the moment condition in the second stage the IV estimates are unbiased. The estimate on  $W_{lo}$  for  $T_{lo}$  is  $(\gamma_1 + \phi_1)$  and the reduced form estimate for  $y_{lo}$  is  $\beta_1(\gamma_1 + \phi_1)$ , so the bias in the reduced form is precisely canceled out by the bias in the first stage.

Second, as shown by Peter Hull in our correspondence, this first stage and reduced form bias will be unaffected by the inclusion of controls  $Z_{lo}$  that are determined in nature if the sample used to estimate those controls is asymptotic, as in the case of standard demographic observables of the individuals in each group or subsample  $lo$  or observable attributes of the groups themselves, which might typically be used in a balancing test. The omission of  $Z_{lo}$  leads to a bias in the models above of the form

$$E[Z_{lo}|W_{lo}, E[W_{lo}]] = \phi_3 W_{lo} + \phi_4 E[W_{lo}]$$

So the inclusion of  $Z_{jk}$  should move estimates by the amount of the bias on the estimate for  $W_{lo}$ . However, given the identification assumptions in BH,  $\phi_3 = 0$  because after conditioning on the expectation the only remaining variation in  $W_{jk}$  is the random shocks, which are

uncorrelated with variables determined in nature. The conditional asymptotic independence of  $Z_{lo}$  and  $W_{lo}$  is the reason that models like these can pass balance even if the first stage is biased.

However, the implication from including high dimensional fixed effects is very different. Specifically, our sample is only asymptotic in the number of clusters  $lo$  in a non-fixed effects model and asymptotic in the number of clusters  $o$  in a model including fixed effects for  $o$ . Therefore, the fixed effect estimates are based on a finite sample and capture information on the actual treatment shocks  $W_{lo}$ . As a result,  $\phi_3 \neq 0$  when  $Z_o$  is a vector of fixed effects over  $o$ , and the first stage estimates can change when high dimensional fixed effects are added as controls.

Next, we present two simple intuitive examples where, like in the more general model above, the moment condition from BH when applied to the first stage unobservable will not hold in a model controlling for a linear function of the aggregation of the shocks and its expectation. Notably, since these examples below arise from the aggregation of take-up for individuals who are exposed to the treatment shock and are making take-up decisions, the second stage unobservable for a sample of individuals who are not making these take-up decisions should still meet the orthogonality conditions in BH after conditioning on the expectation of the aggregate treatment shock.

#### *Aggregate effects of Shocks on Take-up*

Let's start with an individual  $i$ 's take-up of binary treatment,  $t_{ilo} = 0$  or 1, based on binary treatment shocks,  $w_{ilo} = 0$  or 1, and allow take-up to depend upon both the shock that the individual experiences, as well as the aggregate pattern of shocks in the group  $W_{lo}$  where we measure aggregate patterns of take-up and shocks as the sum over all individuals potentially exposed to the shock. We also assume that take-up behavior varies by whether the individual experiences the shock  $w_{ilo} = 1$  or not as denoted below by the  $w$  index on the model parameters. In our application, the parameters  $\gamma_{11}$  and  $\gamma_{21}$  describe the decision to not attend the assigned neighborhood school  $t_{ilo}$  for lottery winners, and  $\gamma_{10}$  and  $\gamma_{20}$  describe the decision process for lottery losers.

$$t_{ilo} = \gamma_{1w_{ilo}} + \gamma_{2w_{ilo}} W_{lo} + \mu_{ilo}$$

Then, given the spillover effects, we can write the aggregate model for  $T_{lo}$  by summing over all individuals in  $lo$  where the sum for observations where  $w_{ilo} = 1$  is just the model multiplied by  $W_{lo}$  and the sum for observations where  $W_{ilo} = 0$  is just the model multiplied by  $(N_{lo} - W_{lo})$ , where  $N_{lo}$  is the number of individuals potentially exposed to the treatment shock (in our example lottery applicants) in group  $lo$ .

$$T_{lo} = \gamma_{10} N_{jk} + ((\gamma_{11} - \gamma_{10}) + \gamma_{20} N_{jk}) W_{jk} + (\gamma_{21} - \gamma_{20}) W_{lo}^2 + \mu_{lo}$$

where  $\mu_{lo}$  is simply the sum of  $\mu_{ijk}$  over all observations in  $lo$ . Taking the conditional expectation of the quadratic term conditional on  $W_{lo}$  and  $E[W_{lo}]$  and using a linear projection yields

$$E[W_{lo}^2 | W_{lo}, E[W_{lo}]] = \phi_1 W_{lo} + \phi_2 E[W_{lo}]$$

where  $\phi_1 \neq 0$  due to the non-linear effects of actual wins, which cannot be captured by the linear control for  $W_{jk}$ . If clusters  $o$  vary in the  $E[W_{lo}]$ , then clusters with higher expectations will tend to have more wins, higher  $W_{lo}$ , leading to this cluster operating on a different portion of the quadratic function. Therefore, conditioning on fixed effects over  $o$  in finite samples captures information on actual wins, absorbs some of the variation in the quadratic term, and so changes the value of the bias  $\phi_1$  in the first stage and reduced form estimates.

#### *Heterogeneous Effects of the Shock over Unobserved Attributes*

The next type of bias that can arise, creating instability in the first stage, comes from heterogeneity in the effect of winning on compliance. Specifically, an individual's unobservables are made up of many attributes  $X_{ilo}$  and the influence of these attributes on whether one takes up treatment (does not attend the assigned school) could vary dramatically based on the treatment shock, e.g., vary between lottery winners and losers. For example,

1. Very strong preference for the specific choice school selected. Presumably, this would have a large impact on leaving the home school if you win, but minimal impact on leaving the home school if you lose the lottery and do not have access to that school.
2. Substantial financial resources. This may not matter that much if you win in terms of not attending the home school because you can simply exercise the option to attend the lottery choice school. However, this could matter a lot for whether you leave the home school if you lose because one of the key ways of leaving if you lose is to move, which takes financial resources.

The resulting estimation model of individual take-up is

$$t_{ilo} = \gamma_1 w_{ilo} + \gamma_2 Pr[w_{ilo}] + (\alpha_1 X_{ilo}) w_{ilo} + (\alpha_2 X_{ilo})(1 - w_{ilo}) + \mu_{ilo}$$

where  $\alpha_1$  and  $\alpha_2$  capture the effect of a vector of unobservable attributes  $X_{ilo}$  on take-up for those who experience the shock  $w_{ilo} = 1$  and those who do not, respectively, and  $\mu_{ilo}$  represents a random stochastic shock remaining after the removal of these unobserved attributes.

Now, we aggregate  $t_{ilo}$  over all individuals at risk of experiencing the treatment shock in  $lo$  to obtain aggregate treatment.

$$T_{lo} = \gamma_1 W_{lo} + \gamma_2 E[W_{lo}] + (\alpha_2 \bar{X}_{lo}) N_{lo} + (\alpha_1 \bar{X}_{jk} - \alpha_2 \bar{X}_{lo}) W_{lo} + \mu_{ilo}$$

where  $\bar{X}_{lo}$  is the mean of the unobserved attributes. The conditional expectation of these terms, which are part of the unobservable, can be written as

$$E[(\alpha_1 \bar{X}_{lo}) | W_{lo}, E[W_{lo}]] = \phi_1 E[W_{lo}]$$

$$E[(\alpha_2 \bar{X}_{lo}) | W_{lo}, E[W_{lo}]] = \phi_2 E[W_{lo}]$$

because  $\bar{X}_{lo}$  is determined in nature and the correlation with  $W_{lo}$  will be zero conditional on  $E[W_{lo}]$ . Taking the conditional expectation of  $T_{lo}$  yields

$$E[T_{lo}|W_{lo}, E[W_{lo}]] = \gamma_1 W_{lo} + (\gamma_2 + \phi_2 N_{lo})E[W_{lo}] + (\phi_1 - \phi_2)W_{lo}E[W_{lo}] + \mu_{lo}$$

Again the conditional expectation depends upon a non-linear function of  $W_{lo}$ , in this case  $W_{lo}E[W_{lo}]$ , leading to a bias in the estimate on  $W_{lo}$ . As above, fixed effects in  $o$  when estimated with finite samples for each value of  $o$  will contain information on the treatment shocks in  $lo$ , and so conditioning on these fixed effects can change the bias in the first stage and in the reduced form estimates.

#### *Empirical Evidence of these Biases in the First Stage*

While we do not claim to know the correct underlying model of lottery winner and loser take-up, i.e., the model that individuals follow when deciding whether to depart from the currently assigned school or not, we have estimated empirical models that allow for the non-linear terms predicted by the models presented above. Specifically, in column 2 of Table C1, we include a control for the interaction of the number of wins minus sample mean number of wins with the number of expected wins, which captures the interaction between number of wins and expected number of wins while allowing the coefficient on number of wins alone to continue capturing an estimate of the effect of the number of wins at the sample mean. Similarly, in column 3, we include controls for the product of the number wins times the number of wins minus the sample mean of the number of wins, and in column 4 we include both controls.

The addition of the interaction of number of wins with expected number of wins (associated with heterogeneous effects of unobservables) is significant and negative, consistent with unobservables that are associated with a high expectation of winning the lottery being correlated with a high propensity to take-up home school departure if losing the lottery. On the other hand, in the fourth column after controlling for both the interaction with expected wins and the square of number of wins, the estimate on the square of expected wins is positive, consistent with a larger effect of the total number of wins on take-up for the lottery winners, relative to lottery losers. This behavior could occur if students in the same neighborhood, both same attendance zone and cohort, are aware that the others have applied and consider those wins as well as their own, as opposed to making decisions individually. Therefore, when many of these students win the lottery, they are all more likely to take-up their offers.

Regardless of the interpretation, the inclusion of these non-linear controls leads to substantial movement in the first stage estimates, even though we provide convincing evidence of passing balance tests conditional on the risk control.

Table C1: First Stage Estimates (With Added Controls)

|                       | N Applicants Attend Different School |                      |                     |                      |
|-----------------------|--------------------------------------|----------------------|---------------------|----------------------|
| Wins                  | 0.469***<br>(0.185)                  | 0.657***<br>(0.170)  | 0.588***<br>(0.123) | 0.411**<br>(0.171)   |
| E[Wins]               | 1.197***<br>(0.223)                  | 1.367***<br>(0.248)  | 1.212***<br>(0.236) | 1.546***<br>(0.281)  |
| (Wins - mean)*E[Wins] |                                      | -0.109***<br>(0.033) |                     | -0.266***<br>(0.087) |
| (Wins - mean)*Wins    |                                      |                      | -0.037<br>(0.047)   | 0.161**<br>(0.078)   |
| Observations          | 8,568                                | 8,568                | 8,568               | 8,568                |

Notes: Estimated first stage equations with additional controls. Outcome is the number of peer applicants who attend a different school in the year after the lottery. Each includes the control for the expected number of wins at the group level. Column 2 also includes the interaction between the demeaned number of wins and the expected number of wins. Column 3 includes an interaction between the demeaned number of wins and the number of wins. Column 4 includes both of the interactions added in Columns 2 and 3. Neighborhood groups include male students in the same cohort, initially assigned neighborhood school, and CBG. Standard errors are clustered at the CBG-Neighborhood School-Cohort level.

## References

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