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The Effect of High School Peers on Juvenile Delinquency*

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In this study, I examine the extent to which the presence of delinquent peers influences students' own delinquency risk by using large administrative data from North Carolina public high schools and state government records. Fixed effect regression estimates, which exploit year-to-year, within-school variation in the share of former delinquents in the ninth-grade cohort, show that having more delinquent high school peers, especially those with similar demographic characteristics, tends to increase a ninth grader's own delinquency risk. A separate analysis of co-offenses committed with formerly delinquent ninth-grade peers shows that co-offending is a potentially important mechanism of delinquency spillovers. I conduct a series of robustness checks and find that the main findings remain robust across alternative specifications.

JEL Classification: I20, J13, K42
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I. Introduction

Juvenile delinquency affects millions of high school students in the United States. Data from the 2017 Youth Risk Behavior Survey by the Centers for Disease Control and Prevention indicate that 23.6% of U.S. high school students were involved in a physical fight, and 6.0% were threatened or injured with a weapon at school during

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the 12 months prior to the survey. A 2015 National Center for Education Statistics report finds that among students between ages 12 and 18, there were more than 1.4 million nonfatal in-school victimization cases in 2013 (Robers et al., 2015). It is also well-documented that the prevalence of criminal offending reaches its peak during the late teenage years (Farrington, 1986).

A reduction in juvenile delinquency would lower the damage and costs incurred by victims, but it could also substantially impact delinquents' subsequent educational, employment, and criminal outcomes. Early contact with the criminal justice system may lead to lower chances of high school graduation (Hjalmarsson, 2008), deterioration of job prospects (Pager, 2003), and higher incarceration rates as adults (Aizer and Doyle, 2015). Given the large costs to victims and delinquents, it is important to improve our understanding of the determinants of juvenile delinquency so that educators and policymakers can design and implement policies that can effectively and efficiently reduce juvenile delinquency.

Peer groups are widely considered to be an important determinant of youth problem behaviors. A large number of studies show evidence of adverse peer effects in youth behavior, such as academic cheating, illicit drug use, underage drinking and smoking, teenage childbearing, and crime (Argys and Rees, 2008; Bayer, Hjalmarsson and Pozen, 2009; Bifulco, Fletcher and Ross, 2011; Billings, Deming and Ross, 2019; Black, Devereux and Salvanes, 2013; Carrell, Malmstrom and West, 2008; Gaviria and Raphael, 2001). Following this line of literature, I examine the extent to which a high school student's own delinquency risk is influenced by the presence of high-risk peers in his/her ninth grade cohort.

An empirical study of student peer effects is usually hampered by the selection problem; students attending different schools are likely to be systematically different in their observable and unobservable characteristics, which may be responsible for the observed correlation between peers' delinquency outcomes. To alleviate the selection problem, I use the fixed effects estimator, exploiting within-school, across-cohort variation in the share of formerly delinquent high school peers as the source of identifying variation. Some schools may always attract more delinquents than others, but the exact year-to-year variation in the share of former delinquents within each school is plausibly uncorrelated with students' own delinquency-relevant characteristics (both observable and unobservable) and thus can be used to identify the causal effect of delinquent peers.

To further mitigate the selection problem, my empirical analysis exploits the mandatory school transition between Grades 8 and 9 and focuses on the within-school, across-year variation in the share of former delinquents among ninth grade peers. Under the usual grade configuration in the U.S., students make the transition from middle school to high school in Grade 9. As the students are all moving to a new school at the same time, it is unlikely that they have accurate information on the share of delinquent peers they will have in ninth grade. On the other hand,

rising eighth and tenth graders should have relatively good information on the share of delinquent peers they will have in Grades 8 and 10, based on the share of delinquent peers they had in Grades 7 and 9. They may then use this information to decide whether to stay in the same middle (high) school or move to a different middle (high) school for Grade 8 (10). Such endogenous school transfer should be less relevant for ninth graders.

My analysis focuses on the empirical relationship between a ninth grader's own delinquency outcome and his/her peers' delinquency history, and its result should be interpreted as a reduced-form estimate of the extent to which the presence of peers with prior delinquency records influences a ninth grader's own delinquency risk. An important limitation of this approach is that it is difficult to separately identify the "exogenous" and "endogenous" peer effects, i.e., how an individual's own behavior is influenced by the (exogenous) characteristics and (endogenous) behavior of his/her peers, respectively (Manski, 1993).[1] Nevertheless, to the extent that within-school, across-cohort variation in the share of former delinquents is exogenous, the analysis should provide internally valid estimates.

Utilizing individual-level administrative data on schooling and juvenile delinquency from the North Carolina public school and juvenile justice systems, my empirical analysis finds that a ninth grader's own delinquency risk tends to increase in the share of ninth grade peers who had a record of juvenile delinquency in the previous year, especially if they both come from the same demographic background. For example, a one percentage point increase in the share of same-race ninth grade peers who committed a delinquent act in Grade 8 is associated with a 0.085 percentage point (2.5%) increase in the likelihood of committing a delinquent act in Grade 9. Likewise, the shares of formerly delinquent ninth grade peers with similar academic and economic backgrounds are significantly and positively correlated with the student's own delinquency risk. These findings are consistent with the existing research evidence on homophily, which shows that individuals are more likely to form close relationships with others who look alike in terms of observable characteristics (McPherson, Smith-Lovin and Cook, 2001). Furthermore, I explore the extent to which the presence of formerly delinquent ninth grade peers affects the probability that other ninth graders co-offend with them and find that co-offending is a potentially important mechanism through which students' delinquency risks are influenced by their formerly delinquent peers.

Although the extent of peer influence on juvenile delinquency and crime has been studied extensively, empirical evidence from detailed administrative data

[1] The endogenous peer effects may be particularly relevant here, since co-offending is fairly common among young offenders. Billings, Deming and Ross (2019) find that more than 20% of all crimes reported to the Charlotte-Mecklenburg Police Department between 2005 and 2013 that led to an arrest of 16-21-year olds were co-offenses. Below, I present a regression analysis which explicitly investigates the effect of peer group composition on co-offending. (See Table 5.)

remains scarce.[2] This study contributes to the literature on peer effects on juvenile delinquency by providing new empirical evidence based on detailed schooling and juvenile delinquency records from North Carolina. These data, which come directly from the state government agencies, make it possible to link a ninth grader's delinquency and crime outcomes with the delinquency and crime histories of their peers. This paper is most closely related to the work of Carrell and Hoekstra (2010), who utilize within-school, across-cohort variation in the share of elementary school peers exposed to domestic violence to estimate the effect of high-risk peers on in-school disciplinary incidents. While using a similar empirical strategy as Carrell and Hoekstra (2010), this study complements and extends their findings by focusing on juvenile delinquency incidents committed by high school students (as opposed to in-school disciplinary incidents committed by elementary school students) and utilizing administrative schooling and delinquency records from the entire state of North Carolina (as opposed to a single school district in Florida). Given that crime and delinquency tend to peak in mid-to-late adolescence, the findings of this paper may be more policy-relevant than those reported by Carrell and Hoekstra (2010).

The rest of the paper is organized as follows. Section 2 reviews existing research on peer effects among youths and introduces the empirical strategy of this study. Section 3 describes school and delinquency data from the North Carolina public school and juvenile justice systems, and Section 4 presents the main results. Section 5 presents the results from a series of validity and robustness checks. Section 6 concludes.

II. Existing Research and Empirical Strategy

The importance of peer effects on youth outcomes, both academic and non-academic, is well known (Sacerdote, 2011). Perhaps this should not be surprising, as youths spend many hours interacting with school and neighborhood peers on a daily basis and tend to be more susceptible to peer pressure than adults. For example, several studies show that peers have an important influence on juvenile delinquency and crime in schools (Carrell and Hoekstra, 2010), neighborhoods (Billings, Deming and Ross, 2019; Billings and Schnepel, forthcoming), and detention facilities (Bayer, Hjalmarsson and Pozen, 2009; Stevenson, 2017).

Non-random peer group formation is arguably one of the most prominent problems that arise when studying the extent of peer effects empirically. In the context of peer effects among students, for example, their school and residential location choices are likely to be endogenous, making peer group formation at the

[2] Notable exceptions include Bayer, Hjalmarsson and Pozen (2009), Carrell and Hoekstra (2010), Billings, Deming and Ross (2019), and Stevenson (2017).

school and neighborhood level correlated with students' observed and unobserved characteristics. Similarly, a student's classroom peers may be determined endogenously if classroom assignments depend on students' academic performance. This selection of students into different schools and classrooms can lead to a positive correlation between students' outcomes even if the causal effect of peers is zero.

One potential remedy for the selection problem is to exploit an institutional setting in which peer groups are determined randomly, such as college roommate assignment (Sacerdote, 2001; Zimmerman, 2003) and squadron assignment at the U.S. Air Force Academy (Carrell, Fullerton and West, 2009). Alternatively, several researchers have used within-school, across-cohort variation in peer composition to obtain causal estimates of peer effects. For example, Hoxby (2000) exploits within-school, across-cohort variation in the share of female students to estimate the effects of having more female peers on academic achievement. Other notable examples in this line of literature include Gould, Lavy and Paserman (2009), Lavy, Paserman and Schlosser (2012), Carrell and Hoekstra (2010), and Carrell, Hoekstra and Kuka (2018). They estimate the extent of peer effects among students by using within-school, across-cohort variation in the share of non-native students (Gould, Lavy and Paserman, 2009), low-achievement students (Lavy, Paserman and Schlosser, 2012), and children exposed to domestic violence (Carrell and Hoekstra, 2010; Carrell, Hoekstra and Kuka, 2018). Their identification strategy is based on the assumption that, while some schools may always attract more non-native students, low-achievement students, and those from troubled families than other schools, the exact year-to-year variation in peer composition in a given school is likely to be exogenous to students' outcome-relevant characteristics.

Following the latter approach, I exploit within-school, across-cohort variation in the share of former delinquents among ninth grade peers to investigate the peer effects on juvenile delinquency. Specifically, I examine how a ninth grader's own delinquency risk is influenced by the share of ninth grade peers who committed an act of delinquency in the previous school year. In order to avoid the problem of potential non-random sorting of students across different classrooms, which may be particularly relevant when studying peer effects among high school students, my empirical analysis focuses on the within-school, across-cohort variation in peer composition.

Using the conventional linear-in-means model, I estimate the following equation:

$$delinq_{ist} = \alpha_0 + \alpha_1 \overline{deling}_{is,t-1} + \alpha_2 x_i + \alpha_3 sc_{st} + \mu_s + \eta_t + \phi_s t + \varepsilon_{ist}, \quad (1)$$

where $delinq_{ist}$ represents whether student i who entered high school s in school year t commits a delinquent act during the same school year t (1 if any, 0

otherwise).[3] x_i denotes student i's observable demographic, economic, and academic characteristics (gender, race, economic disadvantage measured by free or reduced-price lunch eligibility, low academic achievement from eighth grade, and age at ninth grade). sc_{st} denotes characteristics of high school s in school year t, including the shares of male, black, economically disadvantaged, and low-achieving students in the ninth grade cohort (excluding student i), average age of the ninth grade cohort (excluding student i), student–teacher ratio, and the Adequate Yearly Progress (AYP) status. More details about these individual and school-level covariates are provided in Section 3. μ_s and η_t denote school and year fixed effects. $\phi_s t$ represents school-specific linear time trends.[4] ε_{ist} is an idiosyncratic error.

$\overline{delinq}_{is,t-1}$ is the share of student i's ninth grade peers in school s in year t who committed a delinquent act in eighth grade (year $t-1$). The presence of former delinquents may influence a ninth grader's current delinquency risk in multiple ways, such as developing and enforcing antisocial behavior as an acceptable group norm, providing more information about delinquency and criminal skills, and offering more opportunities to commit delinquent acts together. Moreover, the presence of delinquent peers may disrupt other students' learning in the classroom (Lazear, 2001) and adversely affect their academic achievement and educational attainment.

The presence of delinquent peers may have differential impacts on former delinquents and non-delinquents. To keep the analysis simple, my main analysis restricts the estimation sample to students without a delinquency record from Grade 8, and focuses on the effect of having more delinquent peers on those without delinquency records from Grade 8.[5] In Section 5.2, I also present a parallel analysis

[3] I also ran an alternative regression specification in which the number of delinquencies committed in year t is used as an outcome measure. The results, presented in Appendix Table A.1, indicate that having more delinquent peers tends to increase the number of delinquent acts committed in ninth grade.

[4] The specification controls for school-specific linear time trends to account for time-varying, unobserved changes in the school environment that may be relevant to students' delinquency risks. Although this is a widely-used empirical strategy in the literature, it has at least two noteworthy limitations: 1) linear school time trends may not adequately account for the relevant time-varying unobservables if the unobservables follow a highly non-linear trend, and 2) linear school time trends likely confound the time trends of relevant unobservables with the treatment effect of interest, which should affect the school-specific post-treatment trends of the outcome (Goodman-Bacon, 2021). One potential remedy would be to obtain either a linear or higher-order time trend using data from pre-treatment periods only and extrapolate to post-treatment periods. However, the current analysis only considers four cohorts of ninth graders, which makes it difficult to implement this alternative strategy.

[5] A clear distinction between the group of peers who likely provide the source of negative peer influence and those likely affected by them should help isolate the variation in peer characteristics independent of own characteristics (Angrist, 2014). Indeed, a number of studies (Angrist and Lang, 2004; Carrell and Hoekstra, 2010; Carrell, Hoekstra and Kuka, 2018; Gould, Lavy and Paserman, 2009; Lavy, Paserman and Schlosser, 2012) use a similar empirical strategy in which they estimate how the

using the full sample, which includes both former delinquents and non-delinquents.

Under the baseline specification presented above, a ninth grader's delinquency risk is affected by the share of former delinquents in his/her ninth grade cohort. However, the actual peer group with whom a student interacts regularly and feels closely connected is likely smaller than the entire ninth grade cohort. While I do not have information on students' actual peer group networks, existing research shows that students are more likely to form close relationships with other students with similar demographic characteristics, such as gender and race (Currarini, Jackson and Pin, 2010). Moreover, academic ability is likely to be an important determinant of peer group formation in high school, as many U.S. high schools assign students of similar academic ability to the same classrooms, providing them with ample opportunity to become friends. Similarly, students' peer group formation may also be related to their economic background, which can influence their residential locations, types of extra-curricular activities, and out-of-school time use.

Thus, to explore the extent to which delinquency peer effects are concentrated among students with similar characteristics, I regress a ninth grader's delinquency outcome on the shares of former delinquent peers from the same and "opposite" demographic groups, defined by the student's gender, race, academic achievement, and economic status:

$$\overline{delinq}_{igst} = \beta_0 + \beta_1 \overline{delinq}_{igs,t-1} + \beta_2 \overline{delinq}_{ig's,t-1} + \beta_3 x_i + \beta_4 sc_{st} + \mu_s + \eta_t + \phi_s t + \varepsilon_{ist}, \quad (2)$$

where $delinq_{igst}$ is a binary delinquency indicator for student i in demographic group g entering ninth grade in high school s in school year t (1 if committed delinquency in Grade 9, 0 otherwise). $\overline{delinq}_{igs,t-1}$ is the number of student i's ninth grade peers in school s (except student i) who are in the same demographic group g and committed a delinquent act in eighth grade, divided by the number of ninth grade peers from the demographic group g. Similarly, $\overline{delinq}_{ig's,t-1}$ is the share of student i's ninth grade peers in school s who are in the opposite demographic group g' and committed a delinquent act in eighth grade. This specification allows me to separately examine the effects of having more delinquent peers of the same and opposite gender, for example, on student i's delinquency outcome in ninth grade.

My empirical strategy addresses several well-documented problems in the empirical analysis of peer effects. First, I use high school fixed effects to exploit plausibly exogenous variation in peer composition. Although some high schools

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presence of peers from a particular demographic group (e.g., grade repeaters, immigrants, and children exposed to domestic violence) affects the educational outcomes of students from other demographic groups.

may always attract more former delinquents than others, the exact year-to-year, within-school variation in the share of delinquents should be plausibly exogenous to students' delinquency-relevant characteristics. It is important to note that this high school fixed effect specification may not fully account for time-varying differences in unobservable school characteristics (e.g., unexpected decay in school and neighborhood quality over time), even when school-specific time trends are controlled for. However, my empirical analysis considers only four cohorts of ninth graders, and the extent of such time-varying differences is likely to be modest given the short period of analysis. In Section 5, I also explore several alternative specifications and find that significant peer effects among those with similar demographic characteristics mostly remain robust.

Secondly, an important advantage in looking at the ninth grade student population is that most students in the U.S. make the transition from middle school to high school in Grade 9, and the exact number of delinquent peers in the ninth grade cohort in a new school is likely to be unknown to rising ninth graders. By contrast, rising eighth graders and tenth graders should have relatively good information about how many delinquent peers they will have in eighth and tenth grades, based on the number of delinquent peers they had in seventh and ninth grades, respectively. In this case, self-selection may arise if some of the rising eighth and tenth graders transfer to different schools because they had unusually many delinquent peers in the previous school year. This concern should be less relevant to rising ninth graders, who are all moving to a new school at the same time (from middle school to high school) regardless of how many delinquent peers they had in eighth grade. Gibbons and Telhaj (2016) and Ahn and Trogdon (2017) use a similar empirical strategy by utilizing the mandatory school transition and resulting re-mixing of students to estimate the extent of peer effects among students in the UK and US settings.[6]

Third, the identification of peer effects may be hampered by the "reflection problem" and "correlated effects" (Manski, 1993). Researchers usually cannot disentangle the effect of peer behavior on own behavior from the effect of own behavior on peers' behavior (reflection problem) or rule out the presence of unobserved common shocks that may influence all students in the same school to behave similarly (correlated effects). Rather than directly tackling the reflection problem, I instead take a reduced-form approach by focusing on the effect of peers' delinquency history on their own delinquency outcome. A student's delinquent

[6] The possibility of school choice is limited in most school districts across North Carolina. Unless attending private, charter, or magnet schools, most students in North Carolina are simply assigned to their neighborhood school based on pre-determined attendance zone boundaries (Gazze, Persico and Spirovska, 2020). One notable exception is the Charlotte-Mecklenburg School District (CMSD), which has run a school choice program since 2002. However, the inclusion/exclusion of students from CMSD in the analysis has a minimal impact on the estimation results. (See Appendix Table A.2.)

behavior in Grade 9 may be influenced by peers who previously committed delinquent acts in Grade 8, but his/her delinquency outcome in Grade 9 cannot influence the peers' delinquent behavior from the previous year, when many of them attended different middle schools.

Furthermore, given that my empirical analysis focuses on students who move from middle school to high school in Grade 9, the extent of correlated effects should be modest. To confound the estimated peer effect, the unobserved common shock must affect a student's current delinquency outcome in high school (Grade 9) and his/her peers' delinquency histories from middle school (Grade 8) jointly. The concern for such unobserved common shocks should be even less relevant in the alternative specifications considered in Section 5.2, which utilize high-school-by-year fixed effects (Table 8) or variation in the share of delinquent peers coming from different middle schools only (Table 9). Overall, my estimation results may be interpreted as the results from a quasi-experiment in which observably comparable students, namely, ninth graders entering the same high school in different years, are randomly assigned to different types of school peers.

Several existing studies have investigated the magnitude of peer effects on juvenile delinquency, but empirical evidence based on detailed administrative data remains scarce. This study contributes to the literature on peer effects and juvenile delinquency by applying a well-established empirical strategy (i.e., utilizing quasi-experimental variation in the school peer composition across cohorts) to an ideal data set (i.e., detailed individual-level juvenile delinquency and schooling records from the universe of ninth graders in North Carolina public schools). Its findings extend the literature by highlighting the negative spillovers from high-risk peers to low-risk peers, especially among those from the same demographic background, as one of the key determinants of juvenile delinquency.

This paper is most closely related to an influential study by Carrell and Hoekstra (2010), which analyzes student-level data from elementary schools in Florida and finds that students are more likely to commit disciplinary incidents at school when surrounded by more school peers exposed to domestic violence. Both studies use a similar empirical strategy, namely, within-school, across-cohort variation in the share of high-risk peers, namely, children exposed to domestic violence in Carrell and Hoekstra (2010) and ninth graders with prior records of juvenile delinquency in this paper. However, the findings of this paper complement and extend Carrell and Hoekstra (2010) by finding that a similar type of delinquency spillovers is observed among high school students as well. Given that the frequency and severity of delinquency committed by high school students are far greater than those committed by students in elementary school, this finding should be an important, policy-relevant extension of Carrell and Hoekstra (2010). Furthermore, this study utilizes large administrative data from the North Carolina public school system (as opposed to the data from a single school district in Florida used in Carrell and

Hoekstra (2010)), linked with delinquency records from the state juvenile justice system (as opposed to school-provided disciplinary records used in Carrell and Hoekstra (2010)). The use of delinquency records directly obtained from the juvenile justice system should alleviate concerns with potentially different reporting and disciplinary policies across schools. It is noteworthy, however, that the delinquency records collected by the juvenile justice system likely include fewer but more serious acts of delinquency than school-provided disciplinary records.

The findings of this paper are also closely related to Billings, Deming and Ross (2019), which uses administrative schooling data linked with crime and arrest records from Charlotte, North Carolina, to study social spillovers in youth crime. Specifically, they find that a larger share of neighborhood and school peers with similar demographic characteristics leads to an increased probability of committing a crime between the ages of 16 and 21. Moreover, they find that 1) these neighborhood and school peers are likely to commit crime together and 2) the estimated effects of neighborhood peers on youth crime tend to be greater within the same racial and gender groups. Similar to this study, their analysis also utilizes administrative schooling data linked with crime and arrest records and highlights the importance of school peers as a potential determinant of juvenile delinquency. Despite this similarity, our analyses investigate different types of peer influence. While Billings, Deming and Ross (2019) examine peer influence among youths with similar demographic characteristics from the same neighborhood and school ("agglomeration effects"), this study specifically focuses on social spillovers from high-risk to low-risk youths attending the same school, which has strong implications for school and classroom assignment policies for high-risk youths. To the best of my knowledge, this study and Billings, Deming and Ross (2019) are the only two studies that examine peer effects on youth crime and delinquency based on administrative data linking individuals' schooling records with their delinquency and criminal records. Finally, the administrative data from the North Carolina public school system used in this paper had been previously used by other researchers to investigate peer effects on academic achievement; notable examples include Ahn and Trogdon (2017), Diette and Oyelere (2017), Fruehwirth (2013), and Vigdor and Nechyba (2007). However, none of these studies examined the extent of peer effects on juvenile delinquency.

Interestingly, existing research evidence suggests that peer influence plays an important determinant of youth problem behaviors, such as illicit drug use, drinking, smoking, teenage childbearing, academic cheating, and criminal recidivism (Argys and Rees, 2008; Bayer, Hjalmarsson and Pozen, 2009; Black, Devereux and Salvanes, 2013; Carrell, Malmstrom and West, 2008; Figlio, 2007; Gaviria and Raphael, 2001), while evidence on peer effects on academic achievement tends to be more mixed (Ammermueller and Pischke, 2009; Angrist and Lang, 2004; Burke and Sass, 2013; Hanushek et al., 2003; Kang, 2007).

Relatedly, several recent studies use data from randomized school admission lotteries to study the effect of going to a "better" high school on student outcomes (Cullen, Jacob and Levitt, 2006; Deming 2011; Dobbie and Fryer, 2014). These studies find that lottery winners experience fewer arrests and lower incarceration rates on average, while the difference in academic achievement and educational attainment between lottery winners and losers tends to be smaller and less significant. Youth delinquency seems to be a highly relevant empirical setting to study peer effects.

III. Data

The main data source of this study is individual-level administrative data from the North Carolina public school system, provided by the North Carolina Education Research Data Center (NCERDC). The public school data contain information on the academic and demographic characteristics of all students enrolled in the North Carolina public school system. As a measure of students' academic achievement level, I use their performance on North Carolina End-of-Grade (EOG) reading and math tests from Grade 8.[7] The North Carolina Department of Public Instruction divides students' reading and math EOG scores into four levels (achievement levels I, II, III, and IV). I simplify the achievement measures by defining the lowest two achievement levels (levels I and II) as "low-achievement" and the highest two (levels III and IV) as "high-achievement."

The public school data also contain information on students' race, gender, middle school and high school attended, and economic status (measured by free or reduced-price lunch eligibility in eighth grade). Using the information on students' month and year of birth, I compute their age in the fall (September) of ninth grade. Lastly, two school-level characteristics, namely, schools' student–teacher ratio and whether they met the AYP standards each year, are used as proxies of the quality of the learning environment at the school.[8]

Information on juvenile delinquency is taken from juvenile complaint data, provided by the North Carolina Department of Juvenile Justice and Delinquency

[7] The EOG reading and math tests are standard achievement tests administered to students in grades 3 to 8 across the state, often used as indicators of students' academic achievement and school performance in North Carolina.

[8] AYP is a measure used by the U.S. Department of Education to assess the academic performance of every public school in the country each year. The measure is based on students' performance on standardized tests and other academic indicators, such as attendance and graduation rates. Under the federal No Child Left Behind Act of 2001, continued failure to meet the AYP standards can lead to a series of sanctions against low-performing schools. Schools may be required to allow transfers out of the school, offer tutoring services, or have the local education agency take over school management.

Prevention (NJDJJDP) and linked to the student-level schooling data by NCERDC.[9] From the NJDJJDP data, I construct a binary indicator of juvenile delinquency in Grade 8 (9), which is equal to 1 if a complaint was filed against a student during Grade 8 (9) and 0 otherwise.[10] The NJDJJDP data contain the North Carolina students' delinquency records up to age 16, which is the threshold age for legal majority in North Carolina. The five types of most commonly observed juvenile delinquencies are simple assault or affray (14.5%), larceny (7.2%), breaking and entering (4.1%), injury to property (3.9%), and disorderly conduct at school (3.5%).

However, the NJDJJDP data do not provide complete information on delinquency committed by high school students in North Carolina. First, youth offenders under age 16 who commit serious criminal offenses may be transferred to adult courts, and their criminal records would not appear on the NJDJJDP data. Second, students who entered school late or repeated a grade may turn 16 before or during the ninth grade, and their delinquency outcomes may not be observed in the juvenile complaint data.[11] For this reason, my empirical analysis additionally incorporates individual-level adult conviction data, provided by the North Carolina Department of Public Safety (NCDPS) and also linked to the schooling data by NCERDC, and considers whether students commit either juvenile delinquency or adult criminal offense (henceforth "delinquency") in Grade 9 as the main outcome measure.[12]

Notably, information on students' juvenile complaint and criminal conviction outcomes are taken directly from state government agencies (instead of school records), and student delinquency outcomes are observed in the data even if they drop out of high school, as long as they remain in North Carolina. However, students who committed delinquent acts in other states before Grade 9 will be incorrectly listed as non-delinquents, as delinquent acts committed outside North Carolina would not be observed in the NJDJJDP and NCDPS data.

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[9] A complaint filed by a law enforcement o.cer, teacher, or citizen against a youth suspected of committing a crime/delinquency is the first step of the juvenile justice system. An NCDJJDP counselor then evaluates the complaint and takes further steps, such as adjudication and diversion, if necessary. A flowchart that describes the juvenile justice process in North Carolina, as well as different potential outcomes associated with a complaint, is available at https://files.nc.gov/ncdps/div/JJ/JJdiagram.pdf.

[10] I consider delinquent acts committed between August 26 of calendar year t and August 25 of the following year $t+1$ as delinquent acts committed in academic year t.

[11] Twenty percent of the sample students, including both former delinquents and non-delinquents, are 15 years old or above in the fall (i.e., September) of ninth grade.

[12] The number of students who receive a criminal conviction is extremely small. Among students in the full sample, which includes both former delinquents and non-delinquents, 3.9% of ninth graders commit delinquency leading to a juvenile complaint, but only 0.2% commit criminal offense resulting in a conviction. Estimation results remain very similar when adult criminal conviction records are excluded from the delinquency outcome measure.

My empirical analysis considers all students who entered a North Carolina public high school as ninth graders between the 2005–2006 and 2008–2009 school years, with a few sample restrictions. As I utilize the mandatory school transition from middle school to high school in Grade 9, students who attend schools with alternative grade configurations (e.g., schools for 6th to 12th graders) are dropped from the analysis (3% of the unrestricted sample). In order to estimate group-specific peer effects (e.g., peer effects within and across gender and racial groups), the analysis focuses on schools with relatively large ninth grade cohorts, and I drop ninth grade cohorts composed of fewer than 20 students from the analysis (1% of the remaining sample). Lastly, students with missing individual and school characteristics (i.e., gender, race, academic achievement, economic disadvantage, age at Grade 9, student–teacher ratio, and AYP status) are dropped from the analysis (5% of the remaining sample).

[Table 1] Descriptive Statistics

	Non-Delinquents		Delinquents	
	Mean	S.D.	Mean	S.D.
Student Characteristics				
Male	0.495	0.500	0.670	0.470
White	0.582	0.493	0.408	0.492
Black	0.289	0.453	0.478	0.500
Low Academic Achievement, EOG8 Reading or Math	0.333	0.471	0.641	0.480
Economic Disadvantage	0.412	0.492	0.667	0.471
Age, Grade 9	14.7	0.5	15.0	0.6
Delinquency, Grade 9	0.033	0.179	0.292	0.455
School Characteristics				
Number of 9th Grade Peers	324.5	138.1	307.6	131.4
Pupil-Teacher Ratio	15.7	2.5	15.3	2.6
Adequate Yearly Progress (AYP)	0.340	0.474	0.287	0.452
Share of 9th Grade Peers from Same Middle School	0.528	0.326	0.458	0.362
Share of Delinquents among 9th Grade Peers	0.033	0.023	0.047	0.041
Obs.	364,047		11,969	

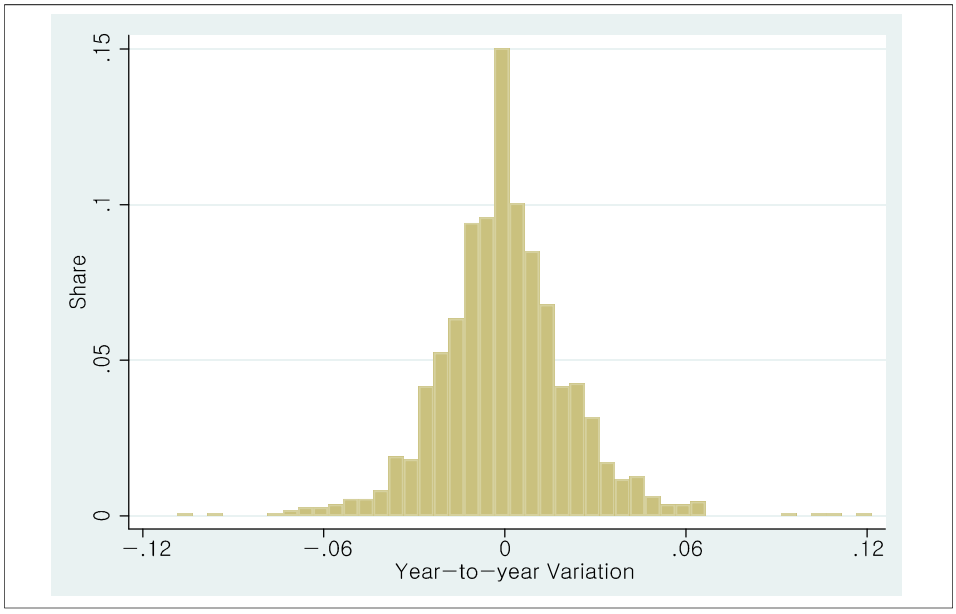
Note: Based on ninth graders in North Carolina public high schools between the 2005–2006 and 2008–2009 school years. Non-delinquents (delinquents) refer to students without (with) a record of delinquency from Grade 8. The number of high schools in the sample is 465.

Table 1 presents descriptive statistics. The main estimating sample ("non-delinquents"), who did not have a delinquency record in eighth grade, is composed of 50% male, 58% white, and 29% black. Thirty-three percent of students have a low academic achievement level in either EOG8 reading or math, and 41% are considered to be economically disadvantaged and eligible for free or reduced-price lunch in Grade 8. Non-delinquents are 14.7 years old when entering ninth grade on average, and 3.3% of them commit an act of delinquency in Grade 9. Compared

with non-delinquents, former delinquents are more likely to be male, black, and economically disadvantaged and have low reading and math academic achievement levels on average. Most importantly, former delinquents are much more likely to commit a delinquent act in Grade 9 than non-delinquents (29% vs. 3%), suggesting that they may be an important source of delinquency peer effects. Lastly, former delinquents on average attend high schools with a slightly larger share of former delinquents and a lower chance of passing the AYP than non-delinquents, but the differences in the ninth grade cohort size and student–teacher ratio between the two groups are relatively small. As noted earlier, the main regression analysis presented below focuses on students with no history of delinquency from Grade 8 and thus does not use their own delinquency history as a regressor.

Figure 1 illustrates the year-to-year, within-school changes in the share of former delinquents in the ninth grade cohort from the sample schools ($N = 465$). The distribution appears to be approximately bell-shaped and centered at zero, but it is clear that there exists non-negligible within-school, across-year variation in the share of former delinquents in the sample, which is used as the key identifying variation in the regression analysis.

[Figure 1] Within-school, Year-to-year Changes in the Share of Former Delinquents in the Ninth Grade Cohort, 2006–2009



Note: The figure plots year-to-year changes in the share of former delinquents among ninth graders within each sample school. Less than 1% of observations (9 out of 1,114) that fall outside the [−0.12, 0.12] range are omitted from the figure.

A key identifying assumption in my empirical strategy is that within-school,

across-cohort variation in the share of former delinquents is uncorrelated with students' own delinquency-relevant characteristics. This assumption should be plausible because most rising ninth graders do not have accurate information on the type of ninth grade peers they will meet in their neighborhood high school, but some exceptions may exist. For example, middle school students and their parents living in a rapidly decaying neighborhood may expect the quality of their neighborhood high schools to continue to fall and the share of formerly delinquent ninth-grade peers to rise. In this case, students who still choose to go to neighborhood high schools may be systematically different from those who move to other neighborhoods or choose to attend a private high school instead. I address this concern by controlling for school time trends in the main specification, but it may not fully account for such endogenous school choice, which would compromise the validity of my analysis.

[Table 2] Validity Check

Outcome:	% Delinquent Peers in Ninth Grade			
	(1)	(2)	(3)	(4)
Male	0.040***	0.037***	−0.000	0.001
	(0.008)	(0.008)	(0.004)	(0.003)
Black	0.483***	0.456***	−0.005	−0.007
	(0.010)	(0.010)	(0.007)	(0.005)
EOG Low	0.294***	0.396***	0.012	0.016**
	(0.009)	(0.009)	(0.009)	(0.007)
Disadvantage	0.487***	0.474***	0.012	0.003
	(0.009)	(0.009)	(0.008)	(0.007)
Age, Grade 9	0.077***	0.058***	0.007	0.006
	(0.008)	(0.008)	(0.005)	(0.004)
Constant	Yes	Yes	Yes	Yes
Year FE	No	Yes	Yes	Yes
High School FE	No	No	Yes	Yes
High School Time Trends	No	No	No	Yes
Observations	364,047	364,047	364,047	364,047
R-squared	0.038	0.047	0.740	0.843

Note: Robust standard errors clustered at the high school level are reported in parentheses. Coefficients and standard errors are in terms of percentage points. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

To explore the empirical relevance of endogenous school choice, I test whether the within-school, across-cohort variation in the share of delinquent peers in the ninth grade cohort is significantly correlated with students' observable characteristics. Table 2 presents estimation results when the share of ninth grade peers with delinquency history (in percentage points) is regressed on five individual covariates (male, black, low academic achievement, economic disadvantage, and age

at Grade 9), year indicators, and high school fixed effects and time trends. Perhaps not surprisingly, the share of delinquent peers is significantly correlated with most individual covariates when high school fixed effects are not controlled for (columns 1 and 2). However, once high school fixed effects and time trends are controlled for (columns 3 and 4), most of the individual characteristics considered are no longer significantly correlated with the share of former delinquents in the ninth grade cohort. While the endogeneity of within-school, across-year variation in the share of former delinquents cannot be completely ruled out, Table 2 suggests that its empirical relevance is likely to be modest.

Table 2 shows little evidence of endogenous school sorting based on the share of former delinquents among ninth grade peers. However, to a certain extent, school sorting may also be driven by the share of former delinquents among upperclassmen in a given school, which may have an important influence on the delinquent behavior of rising ninth graders. Although this can be an important endogeneity concern, the empirical strategy used in this paper is not well suited for separately analyzing the extent of sorting based on the share of formerly delinquent ninth grade peers and the share of formerly delinquent upperclassmen.[13] Nevertheless, I use the same specification as in Table 2 to explore the extent of high school sorting based on the share of former delinquents among tenth graders in the same high school. The estimation results, presented in Appendix Table A.3, are similar to Table 2. The share of former delinquents in the tenth grade cohort in a given school is significantly correlated with most individual characteristics of rising ninth graders (columns 1 and 2), but these correlations become weaker and less significant when high school fixed effects and time trends are controlled for (columns 3 and 4).

IV. Estimation Results

Table 3 presents estimation results from the baseline specification (Equation (1)). In the first column, I regress a binary indicator of ninth grade delinquency on the share of former delinquents in the ninth grade cohort and school year indicators. In the subsequent columns, I additionally control for high school fixed effects (column

[13] Relatedly, an important limitation of my empirical strategy is that it cannot separately estimate the extent of spillovers from ninth grade peers and peers from other grade cohorts (e.g., Grades 10, 11, or 12). For example, if a ninth grader entering a given high school in year t has unusually many delinquent ninth grade peers relative to the overall school-average, this necessarily means that the share of former delinquents in other cohorts (e.g., those who entered the same high school as ninth graders in years $t-1$, $t-2$, and $t-3$) is necessarily smaller than the overall school-average. Given this strong correlation, it becomes difficult to separately estimate the extent of both types of peer influence using this empirical approach.

2), observable individual and school characteristics (column 3), and high-school-specific linear time trends (column 4). Column 2 shows that the inclusion of high school fixed effects substantially lowers the coefficient on the share of former delinquents (from 0.628 to 0.089), which likely reflects that a high degree of selection exists at the high school level. The estimated peer effects further decrease to 0.074 when observable student characteristics are controlled for (column 3). In

[Table 3] Effect of Delinquent Peers in Ninth Grade on Own Delinquency

Outcome:	Delinquency in Grade 9			
	(1)	(2)	(3)	(4)
Share of Former Delinquents	0.628***	0.089**	0.074*	−0.005
	(0.063)	(0.042)	(0.041)	(0.048)
Male			0.015***	0.015***
			(0.001)	(0.001)
Black			0.008***	0.008***
			(0.001)	(0.001)
EOG Low			0.024***	0.024***
			(0.001)	(0.001)
Economic Disadvantage			0.021***	0.021***
			(0.001)	(0.001)
Age, Grade 9			0.002***	0.002***
			(0.001)	(0.001)
Share Male			0.007	0.010
			(0.015)	(0.017)
Share Black			0.041***	0.054***
			(0.015)	(0.020)
Share EOG Low			−0.017**	−0.016
			(0.008)	(0.010)
Share Disadvantage			−0.020**	−0.015
			(0.008)	(0.010)
Grade 9 Peers Average Age			0.023*	0.012
			(0.012)	(0.016)
Student–teacher Ratio			−0.000	−0.000
			(0.000)	(0.000)
Adequate Yearly Progress (AYP)			−0.001	−0.000
			(0.001)	(0.001)
Constant	0.013***	0.032***	−0.354**	−13.008***
	(0.002)	(0.002)	(0.177)	(1.105)
Year FE	Yes	Yes	Yes	Yes
High School FE	No	Yes	Yes	Yes
High School Time Trends	No	No	No	Yes
Obs.	364,047	364,047	364,047	364,047
R-squared	0.007	0.014	0.026	0.028

Note: Robust standard errors clustered at the high school level are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

other words, having three more delinquent peers in a 300-student ninth grade cohort is associated with a 0.07 percentage point (2.2%) increase in a ninth grader's likelihood of committing delinquency. However, when school-specific linear time trends are controlled for (column 4), the estimated effect of formerly delinquent peers on own delinquency becomes small and statistically insignificant.

Next, I estimate Equation (2), in which the ninth grade delinquency indicator is regressed on the shares of delinquent peers from the same and opposite demographic backgrounds, and present the estimation results in Table 4. In column (1), which does not control for school-specific time trends, the likelihood of committing a delinquent act in Grade 9 is significantly and positively correlated with the share of former delinquents of the same sex (0.075) but is more modestly correlated with the share of former delinquents of the opposite sex (0.009) (Panel (A)). Similarly, Panel (B) shows that having more delinquent peers from the same racial group significantly increases the likelihood of committing delinquency in Grade 9 (0.101), but having more delinquent peers from the other racial group has little impact (0.006).[14] Having more delinquent peers from the same academic (Panel C) and economic background (Panel D) also significantly increases the likelihood of own delinquency in Grade 9.

Column (2) of Table 4 presents estimation results from the preferred specification, which additionally controls for school-specific time trends. The coefficient on formerly delinquent ninth-grade peers with similar demographic characteristics somewhat declines when school-specific time trends are controlled for, but the effect of delinquent peers from the same racial (Panel B), academic (Panel C), and economic background (Panel D) remains significantly positive. For example, a one percentage point increase in the share of formerly delinquent peers with similar economic backgrounds increases the probability of own delinquency by 0.09 percentage points (2.7%). For the sake of brevity, I only report estimation results from the preferred specification from this point on.

Potential explanations for the spillovers in juvenile delinquency include the possibility that the presence of high-risk peers increases own delinquency risk by the transfer of criminal knowledge and skills (Bayer, Hjalmarsson and Pozen, 2009) and shifts in the group norm about anti-social behavior (Stevenson, 2017), which may cause the affected youths to commit delinquency on their own. Moreover, the presence of high-risk peers may increase one's own delinquency by providing more opportunities to co-offend, which may be particularly relevant in the context of juvenile delinquency (Billings, Deming and Ross, 2019).

[14] When estimating peer effects from the same and opposite racial groups, the analysis is restricted to black and white students only. Consequently, the sample size slightly decreases from 364,047 to 311,037.

[Table 4] Group-specific Peer Effects

Outcome:		Delinquency in Grade 9	
		(1)	(2)
(A) Share of Former Delinquents by Gender	Same	0.075***	0.035
		(0.025)	(0.028)
	Different	0.009	−0.025
		(0.025)	(0.030)
Obs.		363,928	363,928
(B) Share of Former Delinquents by Race	Same	0.101***	0.085***
		(0.025)	(0.026)
	Different	0.006	−0.004
		(0.008)	(0.010)
Obs.		311,037	311,037
(C) Share of Former Delinquents by EOG Level	Same	0.137***	0.111***
		(0.026)	(0.028)
	Different	−0.009	−0.038**
		(0.015)	(0.018)
Obs.		363,318	363,318
(D) Share of Former Delinquents by Economic Status	Same	0.123***	0.090***
		(0.024)	(0.027)
	Different	−0.029	−0.064***
		(0.018)	(0.020)
Obs.		363,940	363,940
Year FE		Yes	Yes
High School FE		Yes	Yes
High School Time Trends		No	Yes

Note: Each panel corresponds to a separate regression, where a student's ninth grade delinquency outcome is regressed on the share of formerly delinquent ninth grade peers, high school fixed effects and time trends (column 2 only), year indicators, and a set of individual (gender, race, academic achievement level from eighth grade, economic disadvantage, age at Grade 9) and school characteristics (shares of male, black, low academic achievement and economically disadvantaged students among ninth grade peers, average age among ninth grade peers, student–teacher ratio, and the Adequate Yearly Progress indicator). Robust standard errors clustered at the high school level are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

To empirically explore these possibilities, I separately examine the effect of delinquent peers on solo- and co-offenses committed during ninth grade. Direct information on co-offending is not available in the data, but the juvenile delinquency data contain information on the location (i.e., county), date and time, and type of delinquent acts committed. Based on this information, I consider as co-offenses the delinquency cases that occurred in the same county at the same time and date and are of the same type.[15] Then, I re-run Equations (1) and (2) to

[15] By contrast, information on the type of crime committed is not available in the adult criminal

estimate how the probabilities of committing a solo-and co-offense are influenced by the presence of formerly delinquent ninth grade peers. For co-offenses, I consider co-offenses committed with former delinquents as a separate outcome.

Table 5 presents the estimation results. The estimated peer effects on solo-offense (column 1) and co-offense (column 2) are qualitatively similar and mostly positive. However, for both the aggregate and group-specific peer effects, the effect on co-offense tends to be more significant and somewhat larger, especially given that the

[Table 5] Solo- vs. Co-offense

Outcome:		Delinquency in Grade 9		
Type:		Solo-offense	Co-offense	Co-offense with Former Delinquent
		(1)	(2)	(3)
(A) Share of Delinquent Peers		−0.018	0.025	0.020**
		(0.032)	(0.029)	(0.010)
Obs.		364,047	364,047	364,047
(B) Share of Delinquent Peers by Gender	Same	0.009	0.024	0.024***
		(0.020)	(0.018)	(0.007)
	Different	−0.019	0.006	−0.002
		(0.020)	(0.017)	(0.007)
Obs.		363,928	363,928	363,928
(C) Share of Delinquent Peers by Race	Same	0.028	0.057***	0.016***
		(0.018)	(0.016)	(0.005)
	Different	0.004	−0.008	−0.000
		(0.005)	(0.006)	(0.002)
Obs.		311,037	311,037	311,037
(D) Share of Delinquent Peers by EOG Level	Same	0.071***	0.039**	0.022***
		(0.021)	(0.017)	(0.007)
	Different	−0.021	−0.010	−0.000
		(0.013)	(0.010)	(0.004)
Obs.		363,318	363,318	363,318
(E) Share of Delinquent Peers by Economic Status	Same	0.059***	0.033**	0.020***
		(0.020)	(0.015)	(0.006)
	Different	−0.056***	−0.003	0.001
		(0.014)	(0.013)	(0.005)
Obs.		363,940	363,940	363,940
Outcome Variable Mean:		0.026	0.013	0.004

Note: Each column in each panel corresponds to a separate regression, where a student's ninth grade delinquency outcome is regressed on the share of formerly delinquent ninth grade peers, high school fixed effects and time trends, year indicators, and a set of individual and school characteristics listed in Table 2. Robust standard errors clustered at the high school level are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

conviction data. Thus, this analysis on solo-and co-offenses is based on juvenile complaint data only.

since the rate of co-offending observed in the data (1.3%) is much lower than the rate of solo-offending (2.6%). Column (3) reveals that the presence of formerly delinquent peers significantly increases the probability of co-offending with former delinquents across all five specifications considered. Overall, this finding suggests that co-offending is a potentially important mechanism through which the presence of high-risk peers influences one's own delinquency.

Lastly, I examine whether and how the magnitude of peer effects varies across schools with different population sizes. Previous research finds that the magnitude

[Table 6] Group-specific Peer Effects by Ninth Grade Cohort Size

Outcome:		Delinquency in Grade 9			
Cohort Size:		20–199	200–299	300–399	400+
		(1)	(2)	(3)	(4)
(A) Share of Delinquent Peers		−0.104	0.188**	0.259	0.001
		(0.103)	(0.091)	(0.200)	(0.095)
Obs.		63,531	108,037	89,423	103,056
(B) Share of Former Delinquents by Same Gender		−0.018	0.144***	0.144	0.089
		(0.058)	(0.054)	(0.097)	(0.064)
	Different	−0.018	0.051	0.108	−0.094*
		(0.067)	(0.050)	(0.111)	(0.049)
Obs.		63,412	108,037	89,423	103,056
(C) Share of Former Delinquents by Same Race		−0.033	0.019	0.248***	0.218***
		(0.044)	(0.038)	(0.075)	(0.049)
	Different	−0.007	0.010	−0.060	−0.019
		(0.028)	(0.013)	(0.037)	(0.030)
Obs.		50,858	95,135	77,301	87,743
(D) Share of Former Delinquents by Same EOG Level		0.059	0.123**	0.286***	0.154**
		(0.051)	(0.051)	(0.083)	(0.072)
	Different	−0.045	0.022	−0.003	−0.022
		(0.045)	(0.029)	(0.062)	(0.036)
Obs.		62,802	108,037	89,423	103,056
(E) Share of Former Delinquents by Same Economic Status		−0.020	0.147***	0.201**	0.214***
		(0.058)	(0.047)	(0.086)	(0.051)
	Different	−0.075	0.020	−0.010	−0.086***
		(0.051)	(0.039)	(0.084)	(0.031)
Obs.		63,424	108,037	89,423	103,056

Note: Each column in each panel corresponds to a separate regression, where a student's ninth grade delinquency outcome is regressed on the share of formerly delinquent ninth grade peers, high school fixed effects and time trends, year indicators, a set of individual (gender, race, academic achievement level from eighth grade, economic disadvantage, age at Grade 9) and school characteristics (shares of male, black, low academic achievement and economically disadvantaged students among ninth grade peers, average age among ninth grade peers, student–teacher ratio, and the Adequate Yearly Progress indicator). Robust standard errors clustered at the high school level are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

of homophily is greater in schools with a large student population (Currarini, Jackson and Pin, 2010), but it is also plausible that students would closely interact with and more strongly influence their peers in a smaller group setting. To explore the potential heterogeneity in the magnitude of peer effects between smaller and larger schools, I divide the sample into four groups based on the size of the ninth grade cohort, namely, 1) fewer than 200, 2) between 200 and 299, 3) between 300 and 399, and 4) 400 or more students, and re-estimate Equations 1 and 2 separately for each group.

Table 6 presents the estimation results. Although the overall share of delinquent peers is often a statistically insignificant predictor of own delinquency (Panel A), the shares of delinquent peers with similar racial, academic, and economic backgrounds are significant predictors of own delinquency, except for the smallest cohorts made of fewer than 200 students (Panels C, D, and E). One possible explanation is that students in larger ninth-grade cohorts may find it easier to connect with more peers with similar demographic characteristics and form a peer group that significantly influences the behavior of its members.

V. Additional Analyses

5.1. Validity Check

To further explore the validity of my empirical strategy, I also run a placebo test, this time re-estimating the main specification using whether a student committed an act of delinquency in seventh grade as the outcome variable. If the estimates presented in Tables 3 and 4 indeed reflect the causal effect of ninth-grade peer composition on own delinquency, there should be little correlation between the share of ninth-grade delinquent peers and a student's delinquency outcome from seventh grade. On the other hand, if the potential endogeneity in school choice is not fully addressed by high-school fixed effects and time trends, then the share of formerly delinquent ninth grade peers may be closely correlated with one's own delinquency from seventh grade.

An important caveat is that the data on juvenile delinquency and criminal conviction are available for five years only, and the sample used for this placebo analysis slightly differs from the one used for the main analysis. In the main analysis, I examine eighth and ninth grade delinquency records of those who entered a North Carolina public high school as ninth graders between the 2005–2006 and 2008–2009 school years. By contrast, the placebo analysis analyzes seventh and eighth grade delinquency records of those who became ninth graders between the 2006-2007 and 2009–2010 school years. Other sample restrictions, such as grade-level configuration, minimum cohort size, and the availability of individual and

school characteristics, remain the same.

Table 7 presents the estimation results obtained from this placebo analysis. As expected, across most specifications, the share of formerly delinquent ninth grade peers with similar demographic characteristics is no longer a significant predictor of own delinquency in Grade 7, and the estimated coefficients are noticeably smaller than those from the main analysis. The share of delinquent ninth grade peers with similar economic characteristics is the only measure of delinquent peers positively and significantly correlated with one's own delinquency in Grade 7. Although the main specification may not completely address the endogeneity problem, the extent of this problem is likely to be modest.

[Table 7] Placebo Analysis

Outcome:		Delinquency in Grade 7
(A) Share of Delinquent Peers		−0.036
		(0.029)
Obs.		362,214
(B) Share of Former Delinquents by Gender	Same	0.009
		(0.017)
	Different	−0.039**
		(0.017)
Obs.		362,045
(C) Share of Former Delinquents by Race	Same	0.025
		(0.016)
	Different	0.000
		(0.006)
Obs.		304,900
(D) Share of Former Delinquents by EOG Level	Same	0.020
		(0.016)
	Different	−0.055***
		(0.012)
Obs.		361,371
(E) Share of Former Delinquents by Economic Status	Same	0.044***
		(0.017)
	Different	−0.037***
		(0.013)
Obs.		362,189

Note: Each panel corresponds to a separate regression, where a student's seventh grade delinquency outcome is regressed on the share of formerly delinquent ninth grade peers, high school fixed effects and time trends, year indicators, and a set of individual (gender, race, academic achievement level from eighth grade, economic disadvantage, age at Grade 9) and school characteristics (shares of male, black, low academic achievement and economically disadvantaged students among ninth grade peers, average age among ninth grade peers, student–teacher ratio, and the Adequate Yearly Progress indicator). Robust standard errors clustered at the high school level are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

5.2. Alternative Specifications

In this section, I explore several alternative specifications to further explore the validity and robustness of the main findings. First, the high-school-fixed-effects estimator presented above only controls for time-invariant, unobserved school characteristics, and its validity may be compromised in the presence of time-varying, unobservable school characteristics, such as changes in school administration and temporary feuds between local gangs. The inclusion of school-specific linear time trends should alleviate this concern. However, if these time-varying, school-specific shocks do not follow a linear trend, the estimation results may not have a causal interpretation. In light of this limitation, I consider the following specification, which exploits the finding that negative peer effects are mostly driven by delinquent peers with similar demographic characteristics (Table 4).

$$delinq_{igst} = \beta_0 + \beta_1 \overline{delinq}_{igs,t-1} + \beta_2 x_i + \tau_{st} + t_{ist} . \quad (3)$$

Here, a student's ninth grade delinquency outcome $delinq_{igst}$ is regressed on the share of formerly delinquent ninth grade peers with the same demographic characteristics $\overline{delinq}_{igs,t-1}$, individual covariates x_i, and high-school-by-year fixed effects τ_{st}. The key difference here is that only the within-school, across-cohort variation in the share of delinquent peers *with the same demographic characteristic* is used to estimate the extent of peer effects. Estimation results, presented in Table 8, show that the negative spillovers among ninth graders with similar demographic characteristics remain large and significantly positive even after time-varying, unobservable school characteristics are controlled for.

Some middle schools ("feeder school") send most of their graduates to the same high school, and an unusually high share of delinquent ninth grade peers in a given year may simply reflect the presence of unusually many delinquents in the feeder school the year before. In this case, the effect of having more delinquent peers in ninth grade is confounded by the effect of having more delinquent peers from previous school years, and it becomes difficult to interpret the estimated coefficients as the causal effect of having more delinquent ninth-grade peers.

One strategy to alleviate this concern is to focus on the share of delinquent peers from different middle schools as the source of identifying variation. To this end, I estimate Equations (1) and (2) by using the share of delinquent ninth-grade peers who come from different middle schools as an alternative measure of delinquent peers. For this analysis, using simple high school fixed effects is inappropriate, since there is a mechanical, negative correlation between the number of delinquent peers from the same and different middle schools conditional on the high school attended. For students attending the same high school, the number of delinquent peers from

different middle schools is equal to the total number of delinquent peers minus the number of delinquent peers from the same middle school. Then, conditional on the high school attended, having unusually many delinquent peers from other middle schools may simply mean the presence of unusually fewer delinquent peers from the same middle school. Therefore, for this regression analysis, I replace high-school-specific fixed effects and time trends by indicator variables for each middle-school-by-high-school combination observed.

[Table 8] Own-group-specific Peer Effects, School-by-year Fixed Effects Specification

Outcome:	Delinquency in Grade 9
(A) Share of Delinquent Peers, Same Gender	0.065**
	(0.031)
Obs.	364,046
(B) Share of Delinquent Peers, Same Race	0.121***
	(0.028)
Obs.	316,984
(C) Share of Delinquent Peers, Same EOG Level	0.162***
	(0.028)
Obs.	364,044
(D) Share of Delinquent Peers, Same Economic Status	0.160***
	(0.028)
Obs.	364,047

Note: Each panel corresponds to a separate regression, where a student's ninth grade delinquency outcome is regressed on high-school-by-year fixed effects and a set of individual (gender, race, academic achievement level from eighth grade, economic disadvantage, age at Grade 9) characteristics. Robust standard errors clustered at the high school level are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

The first column of Table 9 presents the estimation results. Panel (A) shows that the share of delinquent peers from different middle schools (i.e., the number of delinquent ninth grade peers from different middle schools divided by the number of ninth grade peers from different middle schools) is insignificantly correlated with ninth graders' own delinquency risk. The four subsequent panels separately estimate the impact on the own delinquency of delinquent peers from different middle schools with and without the same demographic characteristics. For example, Panel (B) separately estimates the extent to which a ninth grader's own delinquency risk is influenced by the shares of delinquent peers from different middle schools who are of the same and opposite gender, using the number of peers from different middle schools who are of the same and opposite gender as denominators.

Overall, estimation results presented in the first column of Table 9 indicate that the correlation between a student's own delinquency and the share of delinquent peers with similar demographic characteristics but from different middle schools is

small and mostly insignificant, which may be partly driven by insufficient variation in the share of delinquent peers from different middle schools. More specifically, on average, students in the estimating sample have 10 former delinquents in their cohort (with a total cohort size of 325 students), only four of whom come from different middle schools. To construct an alternative sample with larger variation, I restrict the estimating sample to students whose ninth grade cohorts had 300 or more students and repeat the analysis. The results, presented in the second column of Table 9, indicate that in these larger ninth-grade cohorts, the share of delinquent peers who come from different middle schools and have similar demographic characteristics (i.e., same race, academic achievement level, and economic condition) is a significant predictor of ninth graders' own delinquency risk.

[Table 9] Effect of Delinquent Peers from Different Middle Schools Only

Outcome:		Delinquency in Grade 9	
Sample:		Aggregate	9th Grade Cohort ≥300
		(1)	(2)
(A) Share of Delinquent Peers		−0.008	0.031
		(0.008)	(0.031)
		363,567	192,479
(B) Share of Delinquent Peers by Gender	Same	−0.004	0.029
		(0.007)	(0.018)
	Different	0.002	0.006
		(0.006)	(0.016)
Obs.		360,647	192,479
(C) Share of Delinquent Peers by Race	Same	0.010	0.061***
		(0.006)	(0.017)
	Different	−0.004	−0.018*
		(0.005)	(0.010)
Obs.		293,493	162,352
(D) Share of Delinquent Peers by EOG Level	Same	−0.002	0.050**
		(0.006)	(0.022)
	Different	−0.003	−0.001
		(0.004)	(0.013)
Obs.		357,334	192,479
(E) Share of Delinquent Peers by Economic Status	Same	0.003	0.052***
		(0.006)	(0.020)
	Different	−0.001	−0.006
		(0.005)	(0.013)
Obs.		360,178	192,479

Note: Each panel corresponds to a separate regression, where a student's ninth grade delinquency outcome is regressed on the share of formerly delinquent ninth grade peers from different middle schools, year indicators, a set of individual and school characteristics shown in Table 2, and middle-school-by-high-school fixed effects. Robust standard errors clustered for each middle-school-by-high-school combination are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Next, I extend the main regression specification by additionally controlling for students' neighborhood of residence, taking advantage of students' residential location information at the Census Block Group (CBG) level available in the North Carolina public school data. Using this information, I now control for high-school-by-CBG fixed effects to account for the sample ninth graders' residential locations and re-estimate Equations (1) and (2). One caveat is that the residential location

[Table 10] Census Block Group (CBG) Fixed Effects

Outcome:		Delinquency in Grade 9	
		(1)	(2)
(A) Share of Delinquent Peers		−0.010	0.017
		(0.048)	(0.044)
		315,978	315,978
(B) Share of Former Delinquents by Gender	Same	0.039	0.035
		(0.029)	(0.027)
	Different	−0.030	−0.013
		(0.029)	(0.026)
Obs.		315,892	315,892
(C) Share of Former Delinquents by Race	Same	0.080***	0.058**
		(0.027)	(0.025)
	Different	−0.006	−0.005
		(0.011)	(0.008)
Obs.		271,098	271,098
(D) Share of Former Delinquents by EOG Level	Same	0.101***	0.107***
		(0.029)	(0.026)
	Different	−0.040**	−0.027
		(0.018)	(0.017)
Obs.		315,374	315,374
(E) Share of Former Delinquents by Economic Status	Same	0.080***	0.089***
		(0.027)	(0.026)
	Different	−0.056***	−0.048**
		(0.021)	(0.019)
Obs.		315,966	315,966
High School FE		Yes	No
High-School-by-CBG FE		No	Yes
High School Time Trends		Yes	Yes

Note: Each column in each panel corresponds to a separate regression, where a student's ninth grade delinquency outcome is regressed on the share of formerly delinquent ninth grade peers, high school fixed effects (Column 1) or high school-by-Census Block Group fixed effects (Column 2), high school time trends, year indicators, and a set of individual (gender, race, academic achievement level from eighth grade, economic disadvantage, age at Grade 9) and school characteristics (shares of male, black, low academic achievement and economically disadvantaged students among ninth grade peers, average age among ninth grade peers, student–teacher ratio, and the Adequate Yearly Progress indicator). Robust standard errors clustered at the high school level are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

information is not available for a small number of school districts, and this analysis is necessarily restricted to students from school districts where residential location information is available. The estimation results presented in Table 10 indicate that the estimated effect of delinquent peers remains robust whether or not CBG fixed effects are controlled for.

The last robustness check concerns the choice of the estimating sample. As noted above, all the analyses presented so far exclude former delinquents from the estimating sample. However, juvenile delinquency in Grade 8 is likely to be an endogenous outcome itself, strongly correlated with students' unobservable characteristics. To explore the extent to which my findings are driven by this sample choice, I re-estimate the preferred specification using the full sample, which includes both former delinquents and non-delinquents. Furthermore, given the

[Table 11] Effect of Delinquent Peers in Ninth Grade on Own Delinquency, Full Sample

Outcome:	Delinquency in Grade 9				
	(1)	(2)	(3)	(4)	(5)
Former Delinquent	0.231***	0.231***	0.233***	0.231***	0.231***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Share of Delinq. Peers	0.017				
	(0.050)				
Share of Delinq. Peers, Same Gender		0.055*			
		(0.029)			
Share of Delinq. Peers, Different Gender		−0.014			
		(0.036)			
Share of Delinq. Peers, Same Race			0.095***		
			(0.028)		
Share of Delinq. Peers, Different Race			−0.002		
			(0.011)		
Share of Delinq. Peers, Same EOG				0.131***	
				(0.030)	
Share of Delinq. Peers, Different EOG				−0.051***	
				(0.019)	
Share of Delinq. Peers, Same Econ Status					0.118***
					(0.028)
Share of Delinq. Peers, Different Econ Status					−0.070***
					(0.021)
	376,016	375,890	321,458	375,263	375,908

Note: All regressions control for high school fixed effects and time trends, year indicators and a set of individual (gender, race, academic achievement level from eighth grade, economic disadvantage, age at Grade 9) and school characteristics (shares of male, black, low academic achievement and economically disadvantaged students among ninth grade peers, average age among ninth grade peers, student–teacher ratio, and the Adequate Yearly Progress indicator). Robust standard errors clustered at the high school level are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

change in the sample composition, this time I additionally control for an indicator variable for the student's own Grade 8 delinquency history.

The estimation results from this analysis are presented in Table 11. Students' Grade 9 delinquency is strongly and significantly correlated with their own Grade 8 delinquency history ("Former Delinquent"). More importantly, the estimated effects of delinquent peers on own delinquency tend to be somewhat larger than those obtained from the non-delinquent sample only (presented in Tables 3 and 4), but the difference is rather modest, suggesting that the magnitude of this selection bias is unlikely to be substantial.

VI. Conclusion

Peer groups play an important role in a variety of youth outcomes, including academic achievement, juvenile delinquency, and other problem behaviors. Following this line of literature, this study investigates how the presence of delinquent peers in high school influences students' delinquency risk by utilizing within-school, across-cohort variation in the share of ninth grade peers with delinquency history as the source of an identifying variation.

Taking advantage of large administrative data from the North Carolina public school and juvenile justice systems, I find that a ninth grader's delinquency risk is significantly influenced by the presence of formerly delinquent school peers who come from similar demographic backgrounds. For example, under the preferred specification, I find that a one percentage point increase in the share of formerly delinquent peers from the same racial group increases the probability of juvenile delinquency in ninth grade by 2.5 percent. On the other hand, the presence of delinquent peers from other demographic groups seems to have a more limited impact on students' ninth-grade delinquency outcome. I also find that this type of spillover in juvenile delinquency is more conspicuous in medium- and large-sized high schools and remains robust across alternative specifications considered.

These findings suggest several possible avenues for future research. First, this study provides strong evidence that when empirically studying the extent of peer effects, students with similar demographic characteristics should be a more relevant peer group to consider than the entire grade cohort. Nevertheless, it is likely that students with similar demographic characteristics only provide a crude approximation of a relevant peer group that significantly influences the group members' behavior. More research using actual friendship network data may shed light on the types of peer groups most relevant to youth outcomes (Calvó-Armengol, Patacchini and Zenou, 2009; Card and Giuliano, 2013).

Secondly, the finding that students are disproportionately influenced by peers with similar characteristics calls for more research on student assignment policies,

which may strongly affect the pattern of social interactions and the resulting peer influence in school. A better understanding of peer interaction and influence in school should shed light on optimal school and classroom assignment policies that minimize the incidence of violence, illicit drug use, and other problem behaviors in school given the share of high-risk students in place (Cook and Ludwig, 2006).

Lastly, more research is needed to better understand the mechanism through which exposure to high-risk peers increases the probability of one's own delinquency. The analysis of solo- and co-offending presented in this study shows that the opportunity to co-offend with former delinquents is a potentially important mechanism of juvenile delinquency spillovers (Billings, Deming and Ross, 2019). However, the results also indicate that co-offending may not be the only relevant explanation for spillovers and that low-risk students surrounded by high-risk peers may also become more likely to commit delinquency on their own. An important question that remains is the extent to which this increased tendency to offend is driven by different factors, such as the transfer of criminal knowledge (Bayer, Hjalmarsson and Pozen, 2009) and social contagion of non-cognitive traits (Stevenson, 2017). It is difficult, to say the least, to pursue this research question using traditional administrative data, but the use of new and less conventional data, such as self-reported survey responses and psychological evaluation results, may help future research overcome this challenge.

[Table A.1] Number of Delinquencies Committed as an Outcome

Outcome:		# of Delinquency in Grade 9
(A) Share of Delinquent Peers		0.072
		(0.074)
Obs.		364,047
(B) Share of Former Delinquents by Gender	Same	0.128***
		(0.047)
	Different	−0.006
		(0.060)
Obs.		363,928
(C) Share of Former Delinquents by Race	Same	0.131***
		(0.046)
	Different	−0.007
		(0.013)
Obs.		311,037
(D) Share of Former Delinquents by EOG Level	Same	0.194***
		(0.047)
	Different	−0.055*
		(0.029)
Obs.		363,318
(E) Share of Former Delinquents by Economic Status	Same	0.186***
		(0.044)
	Different	−0.083**
		(0.032)
Obs.		363,940

Note: Each panel corresponds to a separate regression, where the number of delinquent acts committed in Grade 9 is regressed on the share of formerly delinquent ninth grade peers, high school fixed effects (Column 1) or high school-by-Census Block Group fixed effects (Column 2), high school time trends, year indicators, and a set of individual (gender, race, academic achievement level from eighth grade, economic disadvantage, age at Grade 9) and school characteristics (shares of male, black, low academic achievement and economically disadvantaged students among ninth grade peers, average age among ninth grade peers, student–teacher ratio, and the Adequate Yearly Progress indicator). Robust standard errors clustered at the high school level are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

[Table A.2] Delinquency Peer Effects and School Choice

Outcome:		Delinquency in Grade 9	
Charlotte-Mecklenburg School District Excluded:		No	Yes
		(1)	(2)
(A) Share of Delinquent Peers Obs.		−0.005	−0.021
		(0.048)	(0.048)
Obs.		364,047	332,096
(B) Share of Delinquent Peers by Gender	Same	0.035	0.023
		(0.028)	(0.028)
	Different	−0.025	−0.035
		(0.030)	(0.029)
Obs.		363,928	331,995
(C) Share of Delinquent Peers by Race	Same	0.085***	0.079***
		(0.026)	(0.027)
	Different	−0.004	−0.004
		(0.010)	(0.011)
Obs.		311,037	284,593
(D) Share of Delinquent Peers by EOG Level	Same	0.111***	0.094***
		(0.028)	(0.028)
	Different	−0.038**	−0.051***
		(0.018)	(0.017)
Obs.		363,318	331,517
(E) Share of Delinquent Peers by Economic Status	Same	0.090***	0.081***
		(0.027)	(0.027)
	Different	−0.064***	−0.067***
		(0.020)	(0.020)
Obs.		363,940	331,989

Note: Each column in each panel corresponds to a separate regression, where a student's ninth grade delinquency outcome is regressed on the share of formerly delinquent ninth grade peers, high school fixed effects and time trends, year indicators, a set of individual (gender, race, academic achievement level from eighth grade, economic disadvantage, age at Grade 9) and school characteristics (shares of male, black, low academic achievement and economically disadvantaged students among ninth grade peers, average age among ninth grade peers, student–teacher ratio, and the Adequate Yearly Progress indicator). Column (2) excludes students from the Charlotte-Mecklenburg School District, which has run a school choice program since 2002. Robust standard errors clustered at the high school level are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

[Table A.3] Sorting based on Tenth Grade Cohort Composition

Outcome:	% Delinquent Peers in Tenth Grade			
	(1)	(2)	(3)	(4)
Male	0.053***	0.052***	0.002	−0.004
	(0.008)	(0.008)	(0.004)	(0.003)
Black	0.532***	0.520***	0.015**	0.004
	(0.011)	(0.011)	(0.007)	(0.004)
EOG Low	0.350***	0.383***	−0.017**	−0.007
	(0.010)	(0.010)	(0.008)	(0.005)
Disadvantage	0.448***	0.446***	0.001	−0.006
	(0.009)	(0.009)	(0.007)	(0.006)
Age, Grade 9	0.040***	0.032***	−0.011	−0.003
	(0.009)	(0.009)	(0.005)	(0.003)
Constant	Yes	Yes	Yes	Yes
Year FE	No	Yes	Yes	Yes
High School FE	No	No	Yes	Yes
High School Time Trends	No	No	No	Yes
Observations	268,535	268,535	268,535	268,535
R-squared	0.045	0.049	0.765	0.899

Note: Robust standard errors clustered at the high school level are reported in parentheses. Coefficients and standard errors are in terms of percentage points. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

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고등학교 또래집단이 청소년 비행에 미치는 영향*

강 성 만**

초 록 본 연구에서는 미국 노스캐롤라이나 주의 공립학교와 정부 데이터를 이용하여 고등학교 또래집단이 청소년 비행에 미치는 영향을 추정한다. 개별 고등학교에 입학한 신입생 중 전년도 청소년 비행 기록이 있는 학생 비율을 주 설명변수로 사용한 실증 분석 결과, 동급생 중 비행청소년의 비율이 높아질수록 다른 고교 신입생들이 비행을 저지를 확률이 증가하며 이러한 또래효과는 비슷한 인구학적 특성을 가진 학생들 사이에서 강하게 나타남을 발견하였다. 또한 비행청소년의 비율이 높아질수록 이들이 다른 고교 신입생들과 함께 비행을 저지를 확률이 유의미하게 증가하는 것으로 나타났다.

핵심 주제어: 청소년 비행, 또래집단, 동료효과
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