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The Girl Next Door: The Effect of Opposite Gender Friends on High School Achievement†

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This paper finds that a student's share of opposite gender school friends negatively affects high school GPA. It uses the gender composition of schoolmates in an individual's neighborhood as an instrument for the gender composition of an individual's self-reported friendship network. The effect occurs across all subjects for students older than 16, but only in mathematics and science for younger students. Additional results indicate effects may operate inside the classroom through difficulties getting along with the teacher and paying attention, and outside the classroom through romantic relationships. (*JEL* I21, J13, J16)

Are opposite gender friends in high school a distraction or do they promote better academic achievement? Students spend a large amount of time with their school friends (Fuligni and Stevenson 1995; Gager, Cooney, and Call 1999), yet we know little about how the composition of their school friendship networks affects them. Understanding friendship network gender composition speaks to the single-sex education debate to the extent that changes in class and school gender composition affect both the formation of and interactions with opposite gender school friends.

The single-sex versus mixed gender education debate has received renewed attention in the wake of Title IX regulations that eased constraints on single-sex education within the US public school system (Jackson 2012). Single-sex classes and schools may make it easier for educators to address gender gaps in achievement (Fortin, Oreopoulos, and Phipps 2013; Bertrand and Pan 2013; Ku and Kwak 2013) and traits such as competitiveness (Gneezy, Niederle, and Rustichini 2003; Niederle and Vesterlund 2010) that have been shown to affect labor market outcomes (Buser, Niederle, and Oosterbeek 2012). Identifying how the gender composition of a

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student's school friends affects academic achievement distinguishes a potentially important student response of reorganizing class and school gender composition from other effects.

This paper investigates the effect of the share of opposite gender school friends on academic achievement.[1] An instrumental variables approach overcomes the endogeneity of peer composition arising from selection into friendship groups. Students with more opposite gender schoolmates in their close neighborhoods have more opposite gender school friends, and, given that the gender composition of schoolmates in a student's neighborhood is essentially random, provides plausibly exogenous variation in the share of opposite gender friends from which a causal effect on the outcomes of interest can be estimated.

The study makes two contributions to the economics of education literature. First, it shows that an increase in the share of opposite gender school friends reduces academic achievement. To the best of my knowledge, there is no prior evidence of a causal effect associated with the gender composition of an individual's friendship network on academic outcomes.[2] A standard deviation increase in the share of opposite gender friends causes a half standard deviation reduction in GPA scores.

Second, this paper studies potential mechanisms through which friendship network gender composition effects operate. It presents suggestive evidence that an increase in the share of opposite gender friends increases the reported frequencies of difficulties getting along with the teacher and difficulties paying attention in class, two effects occurring within the classroom and generally associated with negative academic outcomes. Results also indicate that opposite gender friends increase the probability of the student being in a romantic relationship, which may have adverse effects on achievement.

These findings are related to but distinct from the literature on cohort gender effects, which generally finds that a higher share of female same-grade schoolmates is associated with better outcomes (for example, Lavy and Schlosser 2011). I consider the gender composition of a student's within-school friendship network, typically a subset of schoolmates in the cohort. Cohort effects may reflect the responses of schools, teachers, and the class environment,[3] while friendship network effects are likely generated by actual peer interactions. In contrast to the cohort composition literature, results indicate that relative gender (same versus opposite) rather

[1] The effect of the share rather than the number of opposite gender friends is modeled in this paper. Many adolescent activities are conducted as friendship groups rather than separately as friendship pairs, making the share of opposite gender friends a salient statistic. For example, a boy with two male friends and two female friends may be more similar to a boy with three male friends and three female friends (same share of opposite gender friends) than another boy with four male friends and two female friends (same number of opposite gender friends). The paper does not preclude the potential for the number of opposite gender friends to have a separate effect.

[2] Poulin, Denault, and Pedersen (2011) attempt to identify an effect using longitudinal variation in the composition of friendship networks, but they cannot account for time-varying changes in unobservable characteristics.

[3] For example, popular educational psychologists who argue that boys and girls learn differently (Gurian 2010) raise the possibility that variation in teaching styles as teachers respond to class composition generates classroom gender composition effects. Under this hypothesis, developing a teaching style suited to both genders may be an appropriate policy response. The finding in this paper that friendship network gender composition effects may operate inside the classroom suggests that within-classroom peer interactions matter, and that policies targeting teaching styles may therefore be inadequate.

than absolute gender (male versus female) is what matters when it comes to friendship network composition effects.

The compositional peer effects[4] estimated in this paper are typically difficult to identify because peer groups are selected; parents choose schools for their children, and teenagers choose their friends. Existing studies examining compositional peer effects on academic achievement have used two broad approaches to overcome peer selection. The first approach exploits the institutional random assignment of peers. Sacerdote (2001); Zimmerman (2003); Stinebrickner and Stinebrickner (2006); and Carrell, Sacerdote, and West (2013) use the random assignment of students to different residences at the same postsecondary institution to investigate the effects of peer characteristics on various student outcomes.[5] The second approach uses variation in the composition of students across grades within the same school to identify compositional peer effects for same-grade schoolmates (within-school cohorts). Prior studies have used this approach to investigate compositional peer effects along multiple dimensions: race (Hanushek, Kain, and Rivkin 2009), domestic violence (Carrell and Hoekstra 2010), home language (Friesen and Krauth 2011), parent characteristics (Bifulco, Fletcher, and Ross 2011) and, related to this paper, gender (Hoxby 2000; Lavy and Schlosser 2011; Schneeweis and Zweimüller 2011). My paper offers a new approach that uses one dimension along which peer groups form (distance) to generate exogenous variation in an orthogonal dimension of peer composition (gender).

This paper also contributes to the literature investigating the role of peer gender composition in the propensity to engage in behaviors associated with drinking, smoking, and teenage pregnancy (Waddell 2012; Fletcher and Ross 2012; Black, Devereux, and Salvanes 2013).

I organize the paper the following way. Section I introduces the empirical methodology, particularly the strategy to overcome the endogeneity in the gender composition of high school friendship networks. The subsequent data section is divided into two subsections. Section IIA provides empirical support for the claim that distance is a significant determinant of friendship, the hypothesis on which the identification strategy relies, and Section IIB describes the data in detail. Results appear in Section III, with subsections corresponding to the primary findings, potential mechanisms, and long-term effects. Section IV provides an overall interpretation of the findings.

[4] Manski (1993) discusses the different types of peer effects. This paper focuses on compositional or exogenous peer effects. Endogenous peer effects operating through the actions and decisions of friends are not modeled in this paper. Estimating these peer effects is the focus of several papers in the economics of education literature (Bramoullé, Djebbari, and Fortin 2009; Cooley 2010; De Giorgi, Pellizzari, and Redaelli 2010; Lin 2010).

[5] This type of random assignment is typically not across genders, limiting the potential for studying gender composition effects, although Whitmore (2005), who uses the class size randomization of Project STAR to investigate the effects of gender composition in elementary school classrooms, provides an exception.

I. Empirical Methodology and Specification

This paper focuses on the effects associated with opposite gender friendships.[6] The academic achievement Y of individual i in grade g and school s is modeled as a linear function of a female indicator F, a vector of remaining individual and background characteristics $\mathbf{X}$, the share of opposite gender friends O, and grade and school fixed effects $\mathbf{D}$:

$$Y_{igs} = \alpha F_i + \beta \mathbf{X}_i + \gamma O_{is} + \delta \mathbf{D}_g + \theta \mathbf{D}_s + \epsilon_{igs}. \tag{1}$$

The model is estimated on the combined sample of males and females, imposing gender symmetry in the effect. I include an interaction term $F_i \times O_{is}$ when gender symmetry is relaxed. This specification shows that the effect of opposite gender friends is negative for both males and females, but is plausibly of different magnitudes (although not statistically different). The advantage of the symmetry restriction is that it increases the statistical power of the estimation.

The gender composition of an individual's high school friendship network is likely to be correlated with a variety of unobservable characteristics that affect academic achievement. Candidates include parental inputs, personality traits, and noncognitive skills. For example, supportive parents may encourage participation in a wide range of extramural activities, resulting in more gender-balanced friendship groups, as well as greater academic achievement. This introduces correlation between the gender composition variable and the error term in the absence of perfect controls for parental inputs.

Peer gender composition is also measured with error. Beyond the attenuation bias associated with potential classical measurement error, friendship networks are constructed from self-reported friendship nominations. This process may yield systematically biased measures of friendship gender composition. For example, some students may nominate opposite gender classmates as friends in an effort to appear more popular, and, if the selection of these students is correlated with their academic achievement, will generate correlation between the share of opposite gender friends and high school performance.

The omitted variables problem and potential measurement error results in least squares estimation of equation (1) providing biased estimates of γ, the effect of the share of opposite gender friends on academic achievement. The challenges in identifying friendship network gender composition are largely distinct from those faced by the literature investigating grade gender composition effects, and a very different approach needs to be taken to the commonly used within-school across-cohort design. This paper exploits variation in the gender composition of schoolmates in

[6] In relation to the network literature, opposite gender friendships are an example of other-type associations. Homophily in friendship networks (the tendency to form same-type friendships) has been extensively modeled in Currarini, Jackson, and Pin (2009). This paper exploits an aspect of the friendship formation process to obtain exogenous variation in friendship network gender homophily from which the causal effects of gender homophily on individual academic achievement and other outcomes can be estimated. It otherwise abstracts away from network formation. See Fletcher, Ross, and Zhang (2013) for a paper that estimates a reduced form matching model to predict friendship formation using the Add Health.

the close neighborhood to obtain exogenous variation in the gender composition of school friends.

I introduce the idea behind the identification strategy with an example. Two females, Alice and Barbara, attend the same school and are in the same grade. They share identical individual and background characteristics, and both live next door to someone who attends the same school. Alice lives next door to a male, Charles, and Barbara lives next door to a female, Debbie. Alice catches the bus with Charles, they are friends, and, in addition, Alice has become friends with some of Charles's (mostly male) friends.[7] Barbara and Debbie also catch the bus together, they are friends, and Barbara is also friends with some of Debbie's (mostly female) friends. As a result, Alice has a larger share of male friends than Barbara. This arose by chance, as both Alice's and Barbara's parents did not know the gender of their neighbors' children when they chose where to live even though both may have based their choices on a variety of other factors, such as income and the proximity to a good school.

The relationship between distance and friendship is central to the identification strategy. The probability of Alice being friends with her neighbor Charles needs to be greater than the probability of Alice being friends with someone identical to Charles who lives on the other side of town. Existing empirical evidence supports the strength of the relationship between distance and friendship. Using the same data as this paper, Mouw and Entwisle (2005) find that friends are more than five times as likely as nonfriends to live within 0.25km of one another after conditioning on several observable characteristics. A further requirement is that there needs to be variation in the gender composition of schoolmates across neighborhoods; the strategy does not work if everyone in the school has one male neighbor and one female neighbor as this would not generate variation in the gender composition of friendship networks. I discuss these conditions further in the data and descriptive statistics section.

The exact instrument used in this paper is a weighted average of the gender composition of someone's nearest twenty same-school neighbors (the set denoted by $J20$ in the specification below). Each neighbor j is identified as being of opposite gender to i by the indicator O_{ijs}, and their contribution to the mean function is weighted by an inverse function of the distance between the relevant individual and the neighbor D_{ijs} (the nearer the neighbor, the greater the weight). The weighting function $w(D_{ijs})$ takes the form of the standard Epanechnikov kernel with bandwidth equal to the distance to the twentieth nearest neighbor D_{J20}.

Results for alternative specifications of the instrument (reported in the online Appendix) indicate that the primary findings do not depend on the functional form of the instrument or the weighting function.[8] The chosen measure was found to be the best approximation of the underlying friendship production function (have the

[7] It is well established that the probability of friendship increases with the existence of mutual friends (see, for example, Goodreau, Kitts, and Morris 2009). This channel is not actually required for the identification strategy to work. It does, however, strengthen it, as the gender composition of Alice's friends is not only affected by her friendship with her male neighbor, Charles, but also by her friendships with Charles' mostly male friends.

[8] The estimates associated with other instruments and weighting functions are generally similar in magnitude, although some are less precise. Weights reflect the probability of friendship being inversely related to spatial proximity. As with any IV strategy, the estimated effect needs to be interpreted as a local treatment effect for variation induced by close neighborhood gender composition.

strongest first stage). I investigate the extent of the bias introduced by selecting the instrument in this way in the online Appendix by bootstrapping the combined instrument selection procedure and IV estimation, showing it to be negligible. The next two equations specify the first stage for investigating the effect of the share of opposite gender friends:

$$(2) \qquad O_{is} = \alpha_0 F_i + \boldsymbol{\beta}_0 \mathbf{X}_{is} + \gamma_0 \frac{\sum_{j \in J20} w(D_{ijs}) O_{ijs}}{\sum_{j \in J20} w(D_{ijs})} + \boldsymbol{\delta}_0 \mathbf{D}_g + \boldsymbol{\theta}_0 \mathbf{D}_s + \nu_{igs}$$

$$(3) \quad w(D_{ijs}) = \frac{3}{4}\left(1 - \left(\frac{D_{ijs}}{D_{J20is}}\right)^2\right).$$

The causal parameter of interest γ in equation (1) is identified if the gender composition of an individual's close neighborhood is restricted to affect academic performance only through the gender composition of the individual's friendship network.[9] Two arguments support this claim.

First, the gender of an individual's neighbor is very likely random. Essentially, parents do not choose the locations of their homes based on the gender of school-going neighbors. The parent component of Add Health includes a question asking the parent their motivation for their residential locational choice, and there is no evidence of neighborhood gender composition playing a role. The full distribution and frequency of reported motivations is provided in the online Appendix. I investigate potential correlation with observables in the online Appendix by performing balance tests in which the instrument is regressed on a set of individual and background characteristics, showing no systematic effect.[10]

Second, I define the friendship network as a set of all ties rather than just strong friendships.[11] Neighbors may exert influence without being strong friends, but are likely to be included in a weak friendship network (that includes both strong and weak ties). Two individuals are defined as friends if either nominated the other individual as a friend rather than the mutual nomination that would be indicative of a strong friendship. (The procedure for nominating and matching friends is discussed in more detail in the data section.) Importantly, this may also include romantic relationships, which cannot be distinguished from other friendships in the observed

[9] In addition to this exclusion restriction, the monotonicity assumption required for instrument validity is very likely satisfied. An individual exposed to an increase in the share of opposite gender close neighbors is unlikely to decrease their share of opposite gender friends.

[10] Angrist and Evans (1998) exploit the fact that girls are more likely than boys to come from larger families, particularly for lower income families. This phenomenon is not found in these data, but conditioning on extensive controls for family structure nonetheless ensure that potential biases arising through this channel are likely alleviated.

[11] Granovetter (1973) is the seminal paper on the importance of weak ties. Several papers have recognized the independent importance of strong ties (Card and Guiliano 2011). Patacchini, Rainone, and Zenou (2012) find that both strong and weak friendships have a contemporaneous effect on high school grades, but only strong friendship effects persist in the long run. This supports using both strong and weak ties when analyzing short run education production. Lavy and Sand (2012) find that different types of friends in the classroom have different effects on learning outcomes for Israeli students transitioning from elementary to middle school, a younger population than that studied in this paper. Results using only strong (reciprocated) friends are reported in the online Appendix with the caveat that this imposes a stricter exclusion restriction.

network, but are subsequently shown to be a candidate mechanism for the effect.[12] An alternative way of thinking about this would be defining the weak friendship network as the set of schoolmates with whom friend-like social interactions occur, and interpreting the friendship network in the data as a proxy for this network.[13]

There are three primary threats to identification. The first is that the gender of schoolmates in the close neighborhood may affect another dimension of an individual's friendship network, and this other dimension of the friendship network may affect achievement. Two primary candidates are friendship network age composition and number of friends. For example, a male with only female schoolmates in the close neighborhood may be more likely to befriend older (or younger) teenagers in the neighborhood, as well as have fewer friends, both of which may affect school performance. These hypotheses are challenged by the finding that the gender composition of close neighbors does not affect the age composition of school friends or the matched number of friends both in the combined sample and separately for males and females.

The second concern is that the gender composition of the close neighborhood may affect the friendship nomination process. For example, low-performing individuals may disproportionately nominate opposite gender neighbors as friends (perhaps to appear more popular) without them actually being friends. The consequence of this would be measurement error in friendship network gender composition (arising from self-reporting bias) being correlated with the instrument in a way that biases results. The online Appendix provides a more formal discussion of this problem, and reports results that contest this hypothesis by showing that a constructed proxy for measurement error in the gender composition of the self-reported friendship network is uncorrelated with the gender composition of the close neighborhood.

The final concern is that neighborhood gender composition is constructed from students attending the sampled school rather than all students in the neighborhood. There may be specific circumstances in which gender differences in the probabilities with which neighborhood students attend the sampled school affect the gender composition of same-school neighbors. For example, the sampled school may be close to a private boy's school that enrolls boys from the wealthier neighborhoods feeding the sampled school. This would result in boys and girls from this neighborhood attending the sampled school having higher and lower shares of opposite gender same-school neighbors, respectively. At the same time, these students are likely to outperform students from other neighborhoods due to their greater family incomes, generating correlation between the gender composition of same-school neighbors and academic achievement that is unrelated to friendship network gender composition. Results contest this hypothesis. As is evident in the above example, effects operating through this channel necessarily affect males and females in opposite directions; this paper finds that both males and females are negatively affected by opposite gender same-school neighbors. Furthermore, the empirical specification

[12] Nominations to individuals residing at the same address are excluded to remove potential sibling gender effects.

[13] Same-school neighbors are not required to be (at least) weak friends for the empirical strategy to be valid; validity just requires that neighbor's gender be orthogonal to achievement if they are not friends.

includes a full set of individual and background characteristics (particularly household income), so any potential biases of this form would need to be generated by unobservable characteristics. And, finally, the online Appendix reports that estimates in rural schools are larger in magnitude than estimates in suburban schools, and given this form of bias is likely limited to suburban schools, it may actually attenuate rather than amplify estimated effects.

Note for exposition that the instrument would be invalid for investigating the race composition of high school friendship networks. This is because race and neighborhood characteristics are not independent. An individual with mostly black same-school neighbors may differ along a number of dimensions to another individual in the same school with mostly white neighbors, even if they share the same observable characteristics.

The negative effect of opposite gender friends on education production may arise from a variety of (nonexclusive) sources. Equation 1 can be interpreted as the reduced form of a simple linear model in which the share of opposite gender friends affects a vector of intermediate mechanisms $\mathbf{W}$, which, in turn, affects academic achievement:[14]

$$W_{m,is} = \alpha_m F_i + \boldsymbol{\beta}_m \mathbf{X}_{is} + \gamma_m O_{is} + \boldsymbol{\delta}_m \mathbf{D}_g + \boldsymbol{\theta}_m \mathbf{D}_s + \eta_{m,igs} \quad \text{for } m = 1, \ldots, M \tag{4}$$

$$Y_{igs} = \alpha_S F_i + \boldsymbol{\beta}_S \mathbf{X}_i + \sum_{m=1}^{M} \gamma_{S,m} W_{m,is} + \boldsymbol{\delta}_S \mathbf{D}_g + \boldsymbol{\theta}_S \mathbf{D}_s + \phi_{igs}. \tag{5}$$

Using the instrument for the share of opposite gender friends in equation (4) identifies the parameter γ_m, the effect of peer gender composition on the candidate mechanism W_m. Evidence that $\gamma_m \neq 0$ (gender composition affects the mechanism) and $\gamma_{S,m} \neq 0$ (the mechanism affects achievement) indicates an operating mechanism W_m, while $\gamma_m = 0$ rejects a candidate mechanism for the peer gender composition effect (although the mechanism could still affect achievement). The parameters $\gamma_{S,m}$ cannot be identified without additional exclusion restrictions (we cannot identify the direct effects of the mechanisms on academic outcomes), so $\gamma_{S,m} \neq 0$ is inferred from non-causal correlations or taken from existing empirical literature. A series of equations taking the form of equation (4) are estimated to investigate the set of mechanisms that may be in operation.

Friendship networks cannot be directly regulated, but policy instruments may be available to act on the channels through which friendship composition effects operate. For example, opposite gender friends exerting negative classroom spillovers but no negative effect outside the classroom would suggest a potential benefit

[14] The parameter of interest in the primary specification $\gamma = \sum_{m=1,\ldots,M} \gamma_{S,m}\gamma_m$, the effect of the share of opposite gender gender friends on achievement, is obtained by summing over each mechanism the products of the effect of that mechanism on the outcome and the effect of the share of opposite gender friends on that mechanism. This model does not allow feedback from the academic outcome to the mechanisms.

from single-sex classrooms in mixed gender schools. Understanding the mechanisms may also inform out-of-sample predictions. The effects of manipulating peer gender composition beyond what was originally observed are predictable only if the mechanisms continue operating in the same way. This is particularly relevant given the evidence in Carrell, Sacerdote, and West (2013) of reduced-form peer effects estimates not informing out-of-sample predictions.

This paper broadly groups candidate mechanisms into those operating within and outside the classroom. First, opposite gender friends may reduce the quality of classroom inputs in the education production function. Abstracting away from the friendship formation process, consider a model in which maintaining (the utility associated with) friendships requires regular interactions. Outside of the classroom, high school students typically engage in a range of gender-specific activities.[15] These activities provide ample opportunities for the same gender interactions that characterize and maintain same gender friendships. The mixed gender classroom provides a relatively scarce opportunity for interactions with opposite gender friends. As a result, individuals in class may distract or be distracted by opposite gender friends more than same gender friends, reducing the quality of classroom inputs for individuals with a greater share of opposite gender friends.

Second, the incentives faced by students outside the classroom may be affected by the gender composition of their friends, and any resulting changes in behavior may have spillover effects on school performance. For example, higher shares of opposite gender friends may increase the returns to leisure and therefore increase the time spent socializing at the expense of studying.

The evidence in the empirical section provides some support for the first set of mechanisms over the second set of mechanisms, although these are somewhat noisily estimated. Romantic relationships are also shown to play a potential role.

II. Data

This paper uses data from the National Longitudinal Study of Adolescent Health (Add Health). The Add Health is a school-based longitudinal study of a nationally representative sample of US adolescents who were in grades 7 to 12 during the 1994–1995 school year. The selected schools were representative of the United States with respect to region of country, urbanicity, size, type, and ethnicity. The core sample was interviewed between April and December 1995 in the first wave of the study. The second wave of the study was conducted the subsequent year, and there have been two further in-home interviews, the most recent being in 2008. This paper primarily uses data from the first wave of the study. The fourth wave of the study is used to investigate the effect of the gender composition of high school friendship networks on long-term outcomes.

[15] Fuligni and Stevenson (1995) and Gager, Cooney, and Call (1999) document typical time use of American teenagers in the 1990s. Fuligni and Stevenson (1995) find that studying, part-time work, extracurricular activities (such as sports), watching television and socializing with friends each consume between 10 and 20 hours per week.

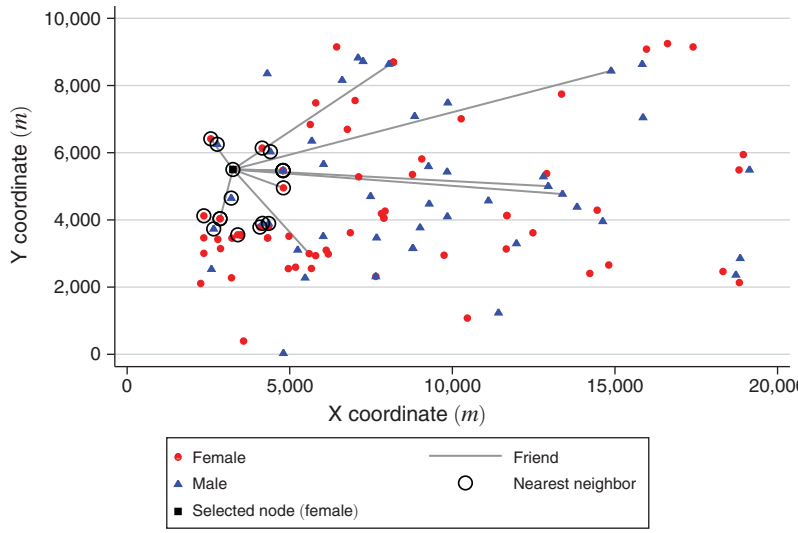

Figure 1. Spatial Distribution within Selected School

Notes: Selected female has 11 friends of which 6 are in the set of 20 nearest schoolmates. There are 152 students in the school.

A. *Distance and Friendship*

There are two aspects of the Add Health study of particular importance: spatial locations and friendship networks. The Euclidean distance between individuals' homes can be calculated from spatial locations recorded in the data. These locations are reported in terms of X- and Y-coordinates for each individual in a school relative to an arbitrary origin. Figure 1 provides an example of the spatial distribution of individuals within a school. This figure highlights the identification strategy. The friendship network for an arbitrarily chosen female individual in the school is shown in gray. Her nearest 20 schoolmates are circled. The gender composition of the individual's friendship network is instrumented by the distance-weighted gender composition of the circled individuals. Six of the selected individual's 11 friends are included in the set of the 20 nearest neighbors; the proportion of matched friends within the 20 nearest neighbors is larger than the proportion of matched friends outside the nearest 20 neighbors, suggesting the role of distance in friendship formation for this individual.

Friendship networks are constructed using data from the first wave of the study. Surveyed individuals were asked to nominate up to five male friends and five female friends.[16] Individuals could leave nominations blank, but could not exceed the limit of five nominations per gender. These nominations were matched to other

[16] Some individuals were asked to nominate only one male and one female friend. The gender compositions of friendship networks computed for these individuals are interpreted as noisier proxies for the gender composition of the underlying friendship network. Results in which the sample is split by the number of friendship nominations or restricted to those with at least two friends are reported in the online Appendix and show that restricting the number of nominations does not affect the primary conclusions of the paper.

Table 1—Descriptive Statistics: Dyadic Pairs

	Mean (standard deviation)		
	All	Males	Females
Distance			
Distance between friends (m)	5,273	5,043	5,506
	(8,404)	(8,199)	(8,602)
	[98]	[136]	[139]
Distance between randomly-drawn schoolmates (m)	7,140	7,038	7,237
	(6,317)	(6,007)	(6,599)
	[68]	[94]	[101]
Gender of nominated friend			
Opposite gender friend	0.37	0.39	0.35
	(0.48)	(0.49)	(0.48)
Female friend	0.52	0.39	0.65
	(0.50)	(0.49)	(0.48)
Interactions with nominated friend			
Go to friend's house	0.38	0.41	0.35
	(0.48)	(0.49)	(0.48)
Meet after school to hang out	0.51	0.53	0.50
	(0.50)	(0.50)	(0.50)
Spend time together during weekend	0.42	0.44	0.41
	(0.49)	(0.50)	(0.49)
Talk about a problem	0.44	0.33	0.55
	(0.50)	(0.47)	(0.50)
Talk on the phone	0.60	0.57	0.64
	(0.49)	(0.50)	(0.48)
Observations	13,142	6,612	6,530
Share	1.00	0.50	0.50

Notes: Reciprocated nominations appear twice in these data. Standard deviations in parentheses. Standard errors in square brackets.

individuals in the same school using school rosters. Sixty-eight percent of friendship nominations by individuals in the sample are matched. Unmatched nominations typically arise from two sources: nominations to individuals in another school or nominations using names that could not be matched on the school roster (for example, nominations using nicknames). The effect investigated in this paper is for the gender composition of matched friends.

This paper primarily defines any nomination or receipt of nomination as a friendship, generating a network of (at least) weak friendships. The subsequent subsection also describes the characteristics of strong friendship networks in which reciprocated nominations generate friendships for comparison purposes. Each friendship nomination generates a dyadic pair. Table 1 describes the interactions of the 13,142 friendship pairs generated by matched nominations in the analyzed sample. Reciprocated nominations appear as two observations in these data, but the reported interactions may differ as they depend on the response of the surveyed individual. The first row of the table provides simple evidence that distance is a significant determinant of friendship. The mean distance between friends

in a school is significantly smaller than the mean distance between two randomly drawn individuals in a school.[17]

Males nominate a higher share of opposite gender friends than females. Slightly fewer than 40 percent of friendship pairs go to each other's home, about half meet after school, and over 40 percent spend time together during the weekend. Forty-four percent of friendship pairs in the data "talk about a problem;" interestingly, but perhaps unsurprisingly, this activity is much more likely in friendship pairs nominated by females. The most common activity among friendship pairs is talking on the phone, which occurs in about 60 percent of friendships in the data.

Table 2 provides evidence that the distance between individuals affects the intensity of their social interactions. This table reports results from regressing binary indicators of each of the interactions with nominated friends discussed above on the distance between the two individuals, the gender (and relative gender) of the nominated friend, and a vector of individual characteristics.[18]

Conditional on being friends, individuals are more likely to go to a friend's house, meet after school and spend time together on the weekend if they live closer together. Distance also affects the likelihood of talking on the phone despite the costs of this activity being independent of spatial proximity. Under the hypothesis that talking on the phone is correlated with the strength of the friendship, this provides suggestive evidence that friends who are geographically proximate have stronger relationships. Females are less likely to meet after school or during weekends and more likely to talk on the phone or about a problem with their nominated friends. All interactions are less likely with opposite gender friends. Given that interactions are more probable with close neighbors, and that these interactions vary by the gender of the nominated friend, the variation in friendship network gender composition induced by the gender composition of close neighbors will affect an individual's weekly interactions in a meaningful manner.

B. *Descriptive Statistics*

The Add Health Wave 1 dataset samples 20,769 individuals from 80 schools.[19] Individuals without core demographic information, GPA scores and spatial locations are dropped. The gender composition of an individual's friendship is only well-defined when the individual has at least one friend. Individuals with no matched friends are therefore dropped from the data. Finally, 4 schools in which fewer than

[17] This comparison does not control for characteristics that may be correlated with the distance between individuals, such as the probability of being the same race. For example, in a school neighborhood in which everyone west of the school is white and everyone east of the school is black, the mean distance between friends may be smaller just because friends are more likely to be of the same race. The evidence that distance affects friendships provided by Mouw and Entwisle (2006) conditions on several observable characteristics including race.

[18] This analysis is only possible within friendship pairs as individuals were not asked about their potential interactions with all other individuals in the school; this would be prohibitively costly in terms of data collection.

[19] About half of the 80 schools are school pairs. School pairs are created to represent one school when the sampled high school does not have lower grades (such as ninth grade). This is done by probabilistically matching high schools without lower grades to one feeder school in the area based on the likelihood with which students come from the set of candidate feeder schools.

Table 2—OLS Estimates of Friend Interactions on Distance

	Dyadic data: all nominations				
	Go to friend's house (1)	Meet after school (2)	Spend time during weekend (3)	Talk about a problem (4)	Talk on phone (5)
Distance quantiles and interactions					
Omitted category: Large distance between friends					
Small distance between friends	0.26***	0.11***	0.14***	0.01	0.05**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Medium distance between friends	0.08***	0.01	0.03	−0.00	0.05**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Female × small distance	−0.05**	−0.00	−0.01	−0.02	−0.05**
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Female × medium distance	−0.03	0.03	−0.01	−0.02	−0.04
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Opposite gender friend × small distance	−0.10***	−0.03	−0.06**	−0.00	−0.03
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Opposite gender friend × medium distance	−0.02	0.02	−0.01	0.04	−0.01
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Female × opposite gender friend × small	0.01	−0.03	0.01	0.01	0.06
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Female × opposite gender friend × medium	−0.01	−0.05	−0.00	−0.07*	−0.00
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Gender and friend gender					
Female	−0.03	−0.04*	−0.04**	0.31***	0.14***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Opposite gender friend	−0.20***	−0.21***	−0.18***	−0.02	−0.09***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Female × opposite gender friend	0.01	0.03	0.03	−0.18***	−0.16***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Observations	13,141	13,141	13,140	13,140	13,140
R^2	0.14	0.10	0.09	0.13	0.09

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

20 students remain in the sample after this process are also dropped. This leaves a final sample of 8,435 individuals from 76 schools.[20]

Descriptive statistics of the key variables used in the paper are reported in Table 3. The primary outcome variable considered in the paper is an overall mean of self-reported grades across four subjects: English, mathematics, science, and history. Letter-grades are converted to numerical grades by assigning fours to As and ones to Ds or lower. The overall mean grade is computed by equally weighting all nonmissing subject grades for each individual. It is 2.8 for the full sample, and 2.7 and 2.9 for males and females, respectively.

[20]The sample includes two Catholic schools and five private schools. Individuals with no matched friends who are dropped from the analysis are not statistically different along observable dimensions from included individuals. See the online Appendix for the distribution of observations by school.

Table 3—Descriptive Statistics: Key Variables

	Mean (standard deviation)		
	All	Males	Females
GPA (A = 4, D or lower = 1; self-reported)			
Overall mean	2.8	2.7	2.9
	(0.8)	(0.8)	(0.8)
Mathematics and science	2.7	2.6	2.8
	(0.9)	(0.9)	(0.9)
English and history	2.9	2.7	3.0
	(0.9)	(0.9)	(0.8)
School friends			
Share opposite gender (any nomination)	0.38	0.38	0.37
	(0.39)	(0.39)	(0.39)
Share opposite gender (reciprocated nomination)	0.17	0.19	0.16
	(0.33)	(0.34)	(0.32)
Nearest 20 schoolmates (weighted)			
Share opposite gender	0.49	0.50	0.49
	(0.14)	(0.14)	(0.14)
School behavioral troubles (Never = 0, every day = 4)			
Trouble getting along with teacher	0.8	0.9	0.7
	(0.9)	(1.0)	(0.9)
Trouble paying attention in class	1.2	1.3	1.1
	(1.0)	(1.0)	(1.0)
Trouble getting homework done	1.2	1.3	1.1
	(1.1)	(1.1)	(1.0)
Trouble with other students	0.8	0.9	0.8
	(1.0)	(1.0)	(1.0)
Friends, relationships, smoking, and drinking behavior			
Number of friends	2.6	2.7	2.6
	(2.6)	(2.6)	(2.6)
Relationship in past 18 months	0.56	0.54	0.57
	(0.50)	(0.50)	(0.49)
Smoked at least one day in past 30 days	0.26	0.26	0.25
	(0.44)	(0.44)	(0.43)
Drunk at least one day in past year	0.28	0.31	0.26
	(0.45)	(0.46)	(0.44)
Long-term outcomes (reduced samples)			
Graduated high school	0.94	0.93	0.95
	(0.23)	(0.25)	(0.22)
Attended college	0.68	0.62	0.72
	(0.47)	(0.48)	(0.45)
Ever married	0.45	0.43	0.46
	(0.50)	(0.49)	(0.50)
Observations	8,435	4,124	4,311
Share	1.00	0.49	0.51

Figure 2 shows the full distribution of overall high school grades by gender. There are two striking differences in the grade distributions for males and females. First, the female distribution is centered at a higher grade (the mode is 3 for females and 2.5 for males), and, second, there is a spike in the distribution for females at scores of 4 (As in all subjects). The mass of females scoring at the top of the distribution is also noted by Fortin, Oreopoulos, and Phipps (2013) and Bertrand and Pan (2013).

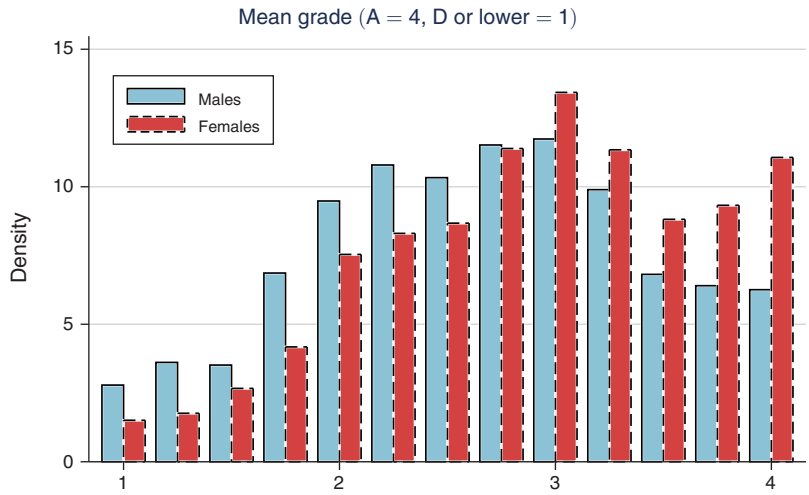

FIGURE 2. DISTRIBUTION OF GRADES

The next set of variables describes the gender composition of high school friendship networks. Recall that individuals must be linked to at least one other individual to be included in the data. The mean share of opposite gender friends is 0.38 in the weak friendship network. This confirms the tendency toward nominating friends of the same gender. I plot the distribution of the mean share of opposite gender friends in Figure 3. This is done for both the full sample and for a restricted sample in which only individuals matched to at least two friends are included. There are mass points at 1 and 0 in the full sample because about 60 percent of the sample were only matched to same-gender friends or were only matched to one friend. The distribution for those with at least 2 matched friends shows the modal share of opposite gender friends to be 0.5, but retains the strong feature of a tendency towards same gender friendships.[21]

The share of opposite gender friends in strong friendship networks (defined by reciprocated nominations) is lower than that found in weak friendship networks. This shows that opposite gender friends are less likely to reciprocate nominations than friends of the same gender.

The instrument is based on the distance-weighted gender composition of each individual's nearest twenty school-going neighbors. The next row of Table 3 shows that the mean share of opposite gender close neighbors (in the same school) is very close to the expected 0.5 in the full sample and for males and females.

The distribution of this variable is important for two reasons. First, there is a concern that all individuals may have a similar share of male and female schoolmates in their close neighborhoods. Under this scenario, even if distance were a significant

[21] The online Appendix reports estimation results for the restricted samples in which at least two friends are matched and at least 75 percent of nominations are matched, respectively. Results are similar to those for the full sample.

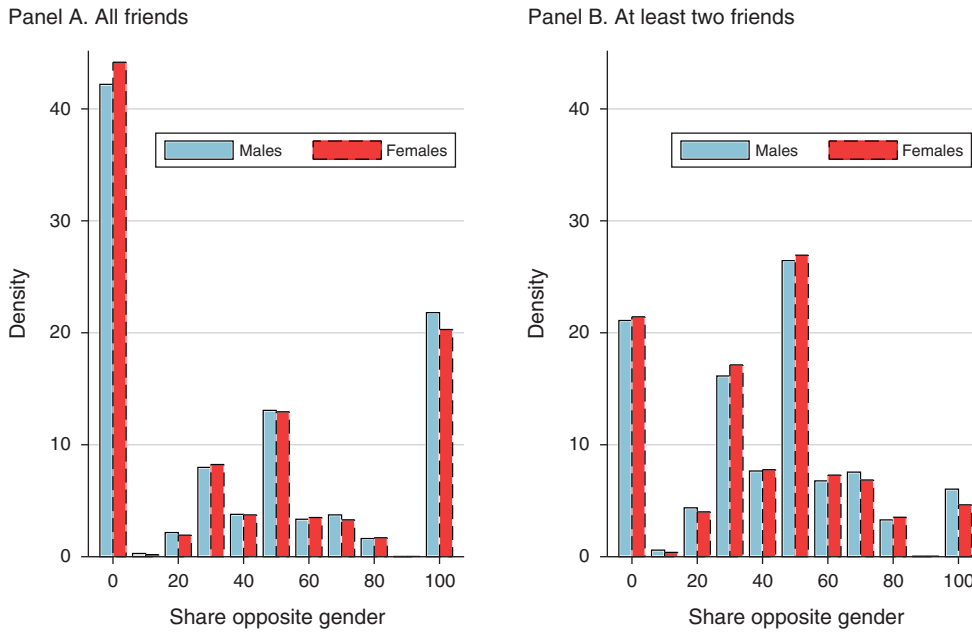

Figure 3. Distribution of Share of Opposite Gender Friends

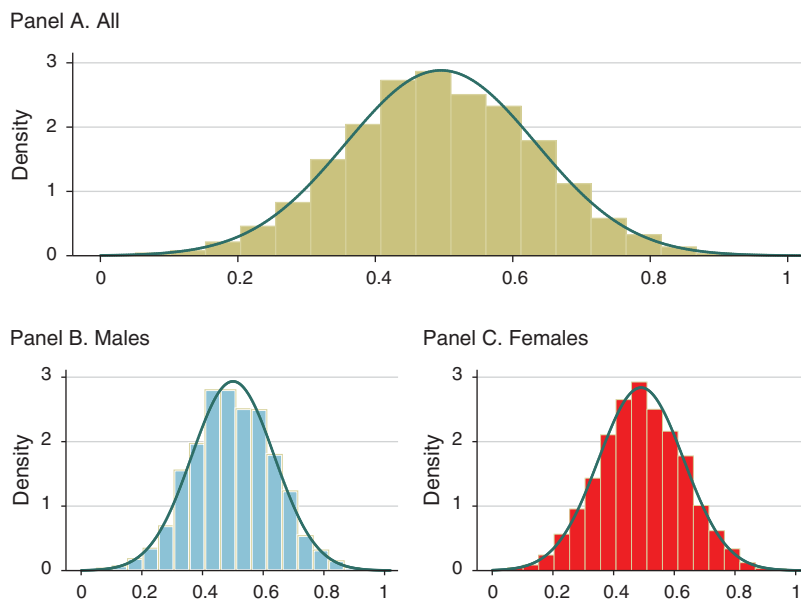

Figure 4. Distribution of Share of Opposite Gender Nearest 20 Neighbors

determinant of friendship, it would not generate variation in the gender composition of friendship networks. The distribution of the weighted gender composition of the nearest 20 neighbors for the full sample, as well as by gender, is plotted in Figure 4, confirming variation in neighborhood gender composition. The interquartile range

(using within-school variation) is 0.2; half the sample have opposite gender friend shares less than 0.4 or greater than 0.6.

Second, the distribution of the share of opposite gender neighbors can be tested for being consistent with a data-generating process in which location decisions are independent of the gender composition of the close neighborhood. We perform a Kolmogorov-Smirnov test for equality of distributions on the observed measure of neighborhood gender composition and a constructed pseudo-measure of neighborhood gender composition in which gender is randomly reassigned to households using even or odd birth months. The null hypothesis of equality of distributions cannot be rejected, supporting the claim that location decisions and the neighborhood gender composition are orthogonal.

The Add Health contains a wealth of information on student behaviors and non-school outcomes. The variables considered in this part of the analysis represent the two major domains through which friendship network gender composition effects are thought to operate: within and outside the classroom. The within-classroom variables are the full set of variables from the Academics and Education component of the study that relate to the recent classroom experience. The variables describing the social and home behaviors of students are considered representative of a broader set of behaviors, and are reported with the caveat that there may be other social and home behaviors for which effects may differ.

Self-reported measures describing the extent to which individuals have behavioral troubles at school are used to provide some support for the hypothesis that the effects identified in this paper may be operating within the classroom. I convert ordinal scales for these variables to numerical scales by assigning zeroes to responses of "Never" and fours to responses of "Every day," the most frequent of five categories. Males are more likely than females to report having both troubles getting along with the teacher and paying attention in school. Both types of troubles occur within the classroom. They are infrequently reported. Considering behaviors outside the classroom, males are more likely to report trouble completing homework and interacting with other students.

Effects may also operate through social activities outside the classroom. An individual's share of opposite gender friends may affect his or her popularity and probability of being in a romantic relationship, both of which may affect academic achievement. The number of friends' variable in Table 3 corresponds to the number of matched friends in the weak friendship network. Conditional on being matched to at least one other individual in the data, individuals have an average of 2.6 matched friends in their weak friendship networks. This is slightly greater for males than females. The reported number of friends is likely to be less than the true number of friends in an individual's school friendship network due to both imposing a maximum number of nominations and some nominations being unmatched.[22] The composition measure used in this paper can therefore be interpreted as a proxy for the true gender composition of the friendship network. Over one half of the sample

[22] It is probable that unmatched nominations occur more frequently within schools in which individuals were less likely to be sampled. Results in which the sample is limited to the set of schools in which all individuals were sampled reveal the same pattern of effects as those reported in this paper.

report being in a relationship in the last 18 months. Females are more likely to report a previous romantic relationship.[23]

An individual's friendship network may also affect smoking and drinking behavior (see, for example, Clark and Lohéac 2007), and smoking and drinking may directly or indirectly affect academic achievement. About one quarter of the sample report smoking at least one day in the past month, and this does not differ by gender. Males are more likely than females to report being drunk at least one day in the past year; just under one-third of males and just over one-quarter of females report this behavior. Various other measures of smoking and drinking behavior were also considered; they convey essentially the same information as these measures.

Finally, we are interested in the persistence of gender composition effects. The long-term outcomes of subsequent-year GPA, graduated high school, attended college, and ever married are taken from the fourth wave of the Add Health study in which individuals are asked about their educational and relationship histories. This wave was conducted in 2008 when individuals were 24 to 32 years old. This is a selected sample as out of the 20,769 respondents from Wave 1, only 15,701 consented to the Wave 4 interview. Descriptive statistics indicate that this is a relatively advantaged population. Ninety-five percent of the sample graduates high school (compared to the national average of around 70 percent) and 68 percent of the sample completes at least 1 year of post-secondary education, the definition of attending college used in this paper. A degree of caution should therefore be exercised when generalizing the long-term results. The probability of males attending college is ten percentage points lower than that for females. Almost one half of the sample report being married (or previously being married).

Core demographic characteristics reported in the online Appendix provide information on the composition of the sample. Just over half the sample is white and one-fifth of the sample is black.[24] Ninety percent of the sample is born in the United States and the mean age is 16, corresponding approximately to the tenth grade. I also report the means of all other control variables, including parent characteristics, home language, household income, family structure, and grade repetition.[25]

III. Results

Opposite gender friends are shown to have a negative effect on high school performance. Subsequent results explore whether the effect differs by gender, across school subjects, and by age. Finally, results investigating the mechanisms through

[23] The behaviors associated with "being in a romantic relationship" are likely to vary considerably across individuals in high school. Finer measures of relationship-type behavior would be required to obtain a fuller picture of the potential effects of peer gender composition.

[24] The Add Health study over-sampled black students. Sample weights are not used in this analysis because their application to friendship pairs is ambiguous; it is not clear how friendships with over-sampled individuals should affect the gender composition of that individual's friendship network. Results are generally insensitive to the inclusion of sample weights at the estimation stage, although they do affect the precision of some of the estimates.

[25] Grade repetition controls are included throughout the paper to control for potential differences in friendship network formation and effects for repeating students. Results are similar if these students are excluded from the analysis.

Table 4—OLS Estimates of GPA on Gender Composition of Schoolmates and Close Neighbors

	Overall GPA (A = 4, D or lower = 1)			
	Gender-symmetric		Gender-specific	
	(1)	(2)	(3)	(4)
School friends				
Share opposite gender: all	0.07***			
	(0.02)			
Share opposite gender: males			0.11***	
			(0.03)	
Share opposite gender: females[b]			0.03	
			(0.02)	
Nearest 20 schoolmates				
Share opposite gender: all		−0.13**		
		(0.06)		
Share opposite gender: males				−0.08
				(0.09)
Share opposite gender: females[b]				−0.18**
				(0.08)
Controls				
Female	0.20***	0.23***	0.19***	0.25***
	(0.02)	(0.02)	(0.02)	(0.06)
Other controls[a]	x	x	x	x
School and grade fixed effects	x	x	x	x
Observations	8,435	8,435	8,435	8,435
R^2	0.24	0.24	0.23	0.23

Notes: Indicator variables for school in saturated sample and period of interview included. Robust standard errors clustered by school in parentheses.

[a] Other controls include individual demographics, parent demographics and education, household income, and family structure.

[b] Estimate obtained by summing share opposite gender and female × share opposite gender coefficients.

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

which peer gender composition affects achievement are reported. Errors are clustered at the school level throughout the analysis.[26]

A. *Effect of Share of Opposite Gender Friends on GPA*

The first and third columns of Table 4 report OLS results from regressing GPA scores on friendship network gender composition measures. The first column reports results from the model that imposes gender symmetry, and the third column reports results from the model that includes a gender interaction on the explanatory variable of interest. Results in these columns show that males with a higher share of opposite gender friends are associated with better school performance (coefficient of

[26] This is conservative given the inclusion of school fixed effects and that the level of variation exploited in this paper is cross-sectional and at the individual level. The precision of estimates obtained without clustering are generally similar.

0.11***), while the correlation for females is close to zero (0.03). As discussed in the methodology section, this correlation could arise from unobserved parental inputs, bias in self-reported friendship nominations or other unobserved characteristics.

The second and fourth columns of Table 4 report the direct effect of the instrument on academic achievement. These estimates have a causal interpretation because the gender composition of same-school neighbors is considered exogenous. The estimated coefficient of −0.13** confirms that an increase in the share of opposite gender schoolmates in the close neighborhood reduces school performance.[27] The fourth column shows that the sign of the effect does not differ by gender, justifying the statistically more powerful gender-symmetric model, but it does suggest that the effect is driven by females (−0.18** for females compared to −0.08 for males). This paper argues that these effects are operating through weak friendship networks.

Goux and Maurin (2007) exploit the institutional environment in France to conclude that an adolescent's outcomes in junior high school are strongly influenced by (and not just correlated with) the performance of neighbors. Foley (2012) finds that neighborhoods affect university participation. The reduced form result in this paper supports the hypothesis that close neighbors matter. It provides a potential mechanism for these findings and suggests that part of the neighborhood effect may be driven by the set of close neighbors that are in an individual's weak friendship network.

The primary causal estimates from the instrumental variable (IV) specification are reported in Table 5. The top panel reports results for the model in which gender symmetry in the effect is imposed. The bottom panel reports results for the model that relaxes gender symmetry, confirming that the effect is the same sign and not statistically different for males and females.

Results for the preferred model include the coefficient of interest and F-statistic from the first stage, as well as a weak IV-robust confidence interval (Schneeweis and Zweimüller 2012). The first-stage coefficients are precise with reasonably sized F-statistics across specifications. The weak IV-robust confidence intervals allow potential nonnormality in GMM statistics arising from weak identification (as discussed in Stock, Wright, and Yogo 2002). Andrews and Stock (2005) advocate inference based on this confidence interval given its robustness properties; opposite gender friends affect academic achievement if the confidence interval is bounded away from zero.

The negative effect of opposite gender friends is evident both without controls (first column; −0.84*) and with controls (second column; −1.05**). The point estimate in the second column is negative and significant, and the corresponding weak IV-robust confidence interval does not include zero. Given the standard deviations of the share of opposite gender friends and mean GPA are 0.4 and 0.8, respectively, the estimate of −1.0 means that a 1 standard deviation increase (0.4) in the opposite gender friend share causes a half standard deviation decline (−0.4) in GPA. Although

[27] This reduced form analysis is also performed on the original sample before individuals with no matched friends are dropped. The estimated coefficient of −0.063 (0.035) is not statistically different from the estimated coefficient of −0.132 (0.055) reported in the table, confirming that the observed pattern is not unique to individuals matched to at least one friend.

Table 5—IV Estimates of GPA on Gender Composition of High School Friendship Networks

	Overall GPA (A = 4, D or lower = 1)		Math and science GPA	English and history GPA
	Gender-symmetric effects			
	(1)	(2)	(3)	(4)
School friends				
Share opposite gender	−0.84*	−1.05**	−1.58**	−0.67
	(0.51)	(0.53)	(0.72)	(0.54)
Weak IV-robust 95 percent CI	[−2.3, 0.1]	[−2.6, −0.2]	[−4.0, −0.5]	[−2.1, 0.3]
First-stage coefficients[a]				
Share opposite gender in close neighborhood	0.13***	0.13***	0.12***	0.13***
	(0.03)	(0.03)	(0.03)	(0.03)
Diagnostics				
F-stat on excluded instrument	16.12	15.32	12.17	15.03
	Gender-specific effects[b]			
	(5)	(6)	(7)	(8)
School friends				
Share opposite gender: males	−0.47	−0.54	−0.89	−0.33
	(0.88)	(0.80)	(1.14)	(0.79)
Share opposite gender: females	−1.28	−1.63	−2.37	−1.05
	(1.05)	(1.15)	(1.79)	(1.04)
p-value of gender difference	0.61	0.50	0.56	0.63
Observations	8,435	8,435	8,169	8,410

Notes: Full set of controls from Table 4 included. Robust standard errors clustered by school in parentheses.
[a] Each coefficient is from the corresponding first-stage regression for that column.
[b] These models include interaction female × share opposite gender, so female estimate obtained by summing share opposite gender and female × share opposite gender coefficients.
***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

the point estimate suggests a moderate to large effect, the relatively wide confidence interval [−2.6, −0.2] includes effects that could be interpreted as small in magnitude.

The IV estimates are consistently of the opposite sign to the (positive) OLS estimates, as well as being larger in magnitude. Individuals with large shares of opposite gender friends are positively selected in terms of academic achievement. This is consistent with the above hypothesis in which motivated parents promote both co-educational extramural activities and school performance. It may also reflect high-achieving students having higher statuses in school and receiving greater shares of friendships nominations from opposite gender schoolmates. There are many alternative hypotheses that would also yield this pattern of selection. The extent of the selection problem make the difference in sign (and magnitude) between the IV and OLS estimates unsurprising; the partial correlation and causal estimates measure very different things in this context. Overall, the OLS-IV difference confirms the importance of an empirical strategy to overcome the endogeneity bias when measuring the effects of friendship network gender composition.

Results in the bottom panel provide suggestive evidence that the effect is larger for females than males. The magnitude of the effect for females is consistently

Table 6—IV Estimates of Academic Achievement by Age

	Overall GPA		Math and science GPA		English and history GPA	
	≤ 16 (1)	> 16 (2)	≤ 16 (3)	> 16 (4)	≤ 16 (5)	> 16 (6)
School friends						
Share opposite gender	−0.70	−1.60**	−1.39*	−1.83*	0.09	−1.88*
	(0.60)	(0.81)	(0.82)	(1.01)	(0.61)	(1.00)
Controls						
Female	0.19***	0.17***	0.14***	0.12***	0.26***	0.23***
	(0.03)	(0.03)	(0.04)	(0.03)	(0.03)	(0.03)
Other controls	x	x	x	x	x	x
School and grade fixed effects	x	x	x	x	x	x
First-stage coefficients						
Share opposite gender	0.14**	0.11**	0.14***	0.09**	0.14***	0.11***
	(0.05)	(0.04)	(0.05)	(0.04)	(0.05)	(0.04)
F-stat on excluded instrument	9.15	8.85	8.76	5.94	9.07	8.82
Observations	4,142	4,293	4,133	4,036	4,134	4,276

Notes: Indicator variables for school in saturated sample and period of interview included. Robust standard errors clustered by school in parentheses.

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

around three times larger than the effect for males (with the caveat that a lack of power prevents statistically distinguishing these estimates).[28]

This paper finds that it is whether school friends are the same or opposite gender rather than male or female that matters for school performance, which distinguishes it from the grade composition literature that generally finds that the share of female schoolmates is positively related to achievement. Despite the relative imprecision of the gender-specific estimates, the null hypothesis that the effect of girls on boys has the same magnitude and opposite sign as the effect of boys on girls is tested and rejected (p-value: 0.06), indicating that peer gender composition effects for school friends are different to peer gender composition effects for same-grade schoolmates.

The subject-specific results reported in the third and fourth columns of Table 5 show that the overall effect is larger in mathematics and science (−1.58**) than English and history (−0.67).[29] This is shown to be driven by the absence of an effect in English and history for individuals under the age of 16 in Table 6. The negative effect of opposite gender friends for girls in their early teenage years in arguably more competitive and traditionally male-dominated school subjects is consistent with gender socialization effects in the existing developmental psychology and economics of education literature: adolescent females may shy away from competition and perform less well in mathematics in the presence of males (Niederle

[28] See the online Appendix for first stage results for the gender interaction model. Although the F-statistics on the excluded instruments are shown to be relatively small, an Anderson-Rubin Wald test providing weak-instrument robust inference indicates that the null hypothesis that the coefficients are jointly equal to zero can be rejected (p-value of 0.04).

[29] Subjects are grouped by type as there are some individuals with missing subject GPA scores and grouping increases the respective sample sizes.

and Vesterlund 2010), although, interestingly, gender differences are not found in a novel paper looking at competitive spelling bees (Smith 2013). The larger effects on females are also consistent with previous studies and the commonly held view that females may have more to gain from single-sex classrooms and schools (Booth, Cardona-Sosa, and Nolen 2013; Schneeweis and Zweimüller 2011). I present this interpretation with the caveat that gender-specific estimates are imprecise.

Results in Table 6 are constructed by splitting the sample at the age of 16. As discussed above, the effect for younger individuals is limited to mathematics and science, while the effect for older individuals is larger and equally prevalent across all school subjects. The smaller and less precise first stage coefficients for older students are consistent with older students being more mobile (the driving age in most states is sixteen). This suggests that the instrument is likely to be less effective for older students as geographic distance becomes a less important determinant of friendship.[30]

B. *Effect of Share of Opposite Gender Friends on Potential Mechanisms*

Results in Tables 7 and 8 explore possible channels through which the share of opposite gender friends affects school performance. Table 7 considers a set of school behavioral troubles and Table 8 investigates social behaviors.[31]

The effects on classroom behavior are of primary importance in the context of the single-sex education debate. There are three major channels through which single-sex classes and schools may affect academic achievement: teachers, the general educational environment, and within-class student interactions are likely affected by and respond to classroom gender composition. Investigating how opposite gender friends affect individuals in the classroom provides important insight into the third channel.

Individuals were asked the frequencies with which they have troubles getting along with the teacher, paying attention in class, getting homework done and relating to other students on a five-point scale (from zero to four with four being the most frequent). The first row of Table 7 (OLS coefficient in GPA regression) reports strong negative correlations between the frequencies of these troubles and GPA scores. Results in the respective columns show that an increase in the share of opposite gender friends increases the frequency of trouble getting along with the teacher and paying attention in class, while the effects on trouble getting homework done and trouble with other students are similarly positive, but imprecisely measured.[32]

[30] The gender-specific effects are imprecisely estimated due to the smaller sample sizes and not reported for this set of regressions, although the pattern of larger effects for females is retained.

[31] The online Appendix reports (non-causal) OLS correlations between these variables and the share of opposite gender friends. A more direct mechanism may operate through the academic ability of peers. As a result of the gender gap in school performance, females with a larger share of opposite gender friends will, on average, have a larger share of less academically able friends. This, in turn, may reduce the school performance of these females. No empirical support for this hypothesis was found; the gender composition of the close neighborhood had no effect on the ability composition of friends for males and females separately, as well as the combined sample. This hypothesis could also only explain the negative effect for females. Males with a larger share of opposite gender (female) friends will, on average, have a larger share of more academically able friends.

[32] The gender composition of friends taking the same classes is correlated (0.7) with the gender composition of all friends. This correlation is computed for a small subsample of individuals for whom indices indicating the extent

Table 7—IV Estimates of Potential Mechanism–School and Classroom Behaviors

	Trouble getting along with teacher	Trouble paying attention in class	Trouble getting homework done	Trouble with other students
OLS coefficient in GPA regression[a]	−0.10***	−0.06***	−0.15***	0.02
	(0.01)	(0.01)	(0.01)	(0.01)
	Gender-symmetric effects			
	(1)	(2)	(3)	(4)
School friends				
Share opposite gender	1.22*	1.27*	1.11	0.69
	(0.73)	(0.75)	(0.76)	(0.58)
Controls				
Female	−0.18***	−0.13***	−0.20***	−0.03
	(0.03)	(0.03)	(0.03)	(0.03)
All other controls	x	x	x	x
	Gender-specific effects			
	(5)	(6)	(7)	(8)
School friends				
Share opposite gender: males	1.50	0.02	0.79	−0.17
	(1.50)	(1.22)	(1.11)	(1.17)
Share opposite gender: females	0.91	2.66*	1.47	1.64
	(1.07)	(1.55)	(1.74)	(1.19)
Observations	8,493	8,492	8,491	8,491

Notes: Indicator variables for school in saturated sample and period of interview included. Robust standard errors clustered by school in parentheses.

[a] Estimates in this row from OLS regression of GPA on potential mechanisms.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

The gender-specific estimates are generally imprecise, but suggest larger estimates for females.

Taken together, these results suggest that an increase in the share of opposite gender school friends negatively affects classroom behavior. High school students appear to be distracted by opposite gender friends in the classroom. This may negatively affect teacher-student relationships, possibly as teachers try to deal with distracted students, and may also reduce the quality of interactions with other students.

The set of mechanisms in Table 8 relate to effects most likely occurring outside the classroom. These effects are less likely to be directly affected by reorganizing classroom gender composition, but may be indirectly affected to the extent that single-sex classes and schools affect friendship network composition. An absence of opposite gender classmates may reduce the share of opposite gender friends, which would affect mechanisms operating both within and outside the classroom. The

of shared courses with schoolmates was available. This supports using the measure of gender composition based on all friends when investigating friendship network gender composition effects inside the classroom. More data would be required to precisely estimate and separate the effects of class-specific and general school friends.

Table 8—IV Estimates of Potential Mechanism–Social and Home Behaviors

	Number of friends	Relationship in past 18 months	Smoked in past 30 days	Drunk in past year
OLS coefficient in GPA regression[a]	0.02***	0.00	−0.29***	−0.13***
	(0.01)	(0.01)	(0.03)	(0.02)
	Gender-symmetric effects			
	(1)	(2)	(3)	(4)
School friends				
Share opposite gender	−1.73	0.89**	−0.08	0.31
	(1.13)	(0.38)	(0.28)	(0.26)
Controls				
Female	−0.03	0.05***	−0.00	−0.04***
	(0.05)	(0.02)	(0.02)	(0.01)
All other controls	x	x	x	x
	Gender-specific effects			
	(5)	(6)	(7)	(8)
School friends				
Share opposite gender: males	−0.64	1.24*	−0.04	0.68
	(1.43)	(0.69)	(0.55)	(0.50)
Share opposite gender: females	−2.96	0.49	−0.12	−0.09
	(2.89)	(0.72)	(0.55)	(0.48)
Observations	8,497	8,416	8,440	8,483

Notes: Indicator variables for school in saturated sample and period of interview included. Robust standard errors clustered by school in parentheses.

[a] Estimates in this row from OLS regression of GPA on potential mechanisms.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

selected variables correspond to popularity (number of friends), romantic relationships, and smoking and drinking behavior. They are intended to reflect a broad set of social behaviors that parents and teachers consider important rather than a complete analysis of all potential channels.

The only significant gender composition effect among this set of mechanisms operates through the probability of being in a romantic relationship (0.89**). An exogenous increase in the share of opposite gender friends increases the likelihood of reporting being in a romantic relationship in the past 18 months. High school romantic relationships may reduce both the quality and quantity of homework and studying if students spend time with their romantic partners, as well as be distracting in the classroom. The direct effect of romantic relationships on achievement cannot be separately identified without an additional exclusion restriction.[33] This finding is also presented with the caveat that reorganizing classroom gender composition may have a limited effect on the probability of being in a romantic relationship, which is important when relating it to the single-sex education debate.

[33] The existing literature finds a correlation but cannot make a strong case for a causal relationship between romantic relationships or sexual activity and high school achievement (Halpern et al. 2000; Sabia 2007).

Table 9—IV Estimates of Selected Mechanisms by Age

	Trouble getting along with teacher		Trouble paying attention in class		Relationship in past 18 months	
	≤ 16 (1)	> 16 (2)	≤ 16 (3)	> 16 (4)	≤ 16 (5)	> 16 (6)
School friends						
Share opposite gender	0.76	1.60**	0.36	2.41**	0.09	1.89***
	(0.95)	(0.77)	(0.79)	(1.11)	(0.47)	(0.66)
Controls						
Female	−0.19***	−0.18***	−0.12***	−0.14***	0.03	0.07**
	(0.04)	(0.03)	(0.03)	(0.04)	(0.02)	(0.03)
Other controls	x	x	x	x	x	x
School and grade fixed effects	x	x	x	x	x	x
Dependent variable						
Mean	0.94	0.74	1.19	1.27	0.46	0.65
[standard deviation]	[0.99]	[0.89]	[1.00]	[1.03]	[0.50]	[0.48]
Observations	4,141	4,293	4,141	4,292	4,133	4,283

Notes: Indicator variables for school in saturated sample and period of interview included. Robust standard errors clustered by school in parentheses.

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Interestingly, I show that an individual's share of opposite gender friends has no clear effect on smoking and drinking, which are intended to reflect nonschool socializing and risk-taking. There is no evidence that opposite gender friends encourage potentially detrimental "cool" behavior.

The gender-specific effects for social behaviors are imprecisely estimated.

The sample is split by age to investigate differences in the mechanism for younger and older students. Results in Table 9 provide further analysis of the three potential mechanisms for which precise estimates were obtained. The increased troubles in the classroom and probability of being in a romantic relationship are strongly evident for older high school students, but not for younger students. This is consistent with the negative effect in mathematics and science for younger students being a consequence of broader gender socialization effects (such as females shying away from competition) rather than any of the direct effects considered here.

C. *Long-Term Effects and Robustness of Empirical Strategy*

Results in Table 10 consider the effect on four long-term outcomes of interest: subsequent-year GPA scores, graduated high school, attended college, and ever married.[34] These outcomes are measured in Wave 4 of the Add Health study conducted

[34] The gender composition of an individual's friendship network is likely to fluctuate during high school as individuals move in and out of friendship groups. The Add Health study included friendship nominations during both the initial in-school interview (in which a brief survey was admitted to all individuals in each sampled school) and the subsequent Wave 1 interview (conducted on a subset of individuals at each school). The correlations between the friendship network gender compositions are positive and significant, varying between 0.3 and 0.5. This correlation confirms the presence of an enduring component in peer gender composition, suggesting the potential for

Table 10—IV Estimates of Long-term Effects of Peer Gender Composition

	Subsequent year GPA (1)	Graduated high school (2)	Attended college (3)	Ever married (4)
School friends				
Share opposite gender	−0.68	−0.13	−0.13	0.52**
	(0.52)	(0.11)	(0.25)	(0.26)
Controls				
Female	0.19***	0.01	0.08***	0.04***
	(0.02)	(0.01)	(0.01)	(0.01)
All other controls	x	x	x	x
Observations	5,822	6,646	6,647	5,894

Notes: Indicator variables for school in saturated sample and period of interview included. Robust standard errors clustered by school in parentheses.
***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

in 2008; the sample is substantially smaller due to attrition. Estimates suggest an imprecise, negative effect of the opposite gender share of friends on the three academic outcomes, and a significant positive effect on the probability of ever being married. The latter finding is not surprising given that an increase in the share of opposite gender friends increases the probability of being in a romantic relationship in high school, and the likely correlation between this and ever being married. These results suggest persistence in the peer gender composition effects associated with high school friendship groups.

Turning to the robustness of the empirical strategy, Figure 5 plots the mean share of opposite gender close neighbors for four categories of mother's and father' education, as well as annual household income. The absence of a systematic pattern in the gender composition of close neighbors provides evidence that the instrument is balanced across observables. Plots for the share of white same-school neighbors are included for comparison. As expected, the share of white same-school neighbors is correlated with socioeconomic indicators, indicating that it could not be interpreted as a random treatment. An additional balance test is performed by predicting GPA from the full set of observables, and running the IV regression on predicted rather than actual GPA. Given that the share of opposite gender close neighbors should be uncorrelated with observables, the component of opposite gender friends predicted by opposite gender close neighbors should also be uncorrelated with the component of GPA predicted by the observables. The estimated coefficient is −0.02 (0.34), providing further support for the exogeneity of the instrument. I report and discuss further robustness checks in the online Appendix. These show that the pattern of results is not affected by the functional form of the instrument, the school-specific nomination process or the chosen definition of friendship.

long run effects. Wave 1 friendship nominations generate the opposite gender friend shares used in this paper as outcomes and spatial locations are obtained from this wave.

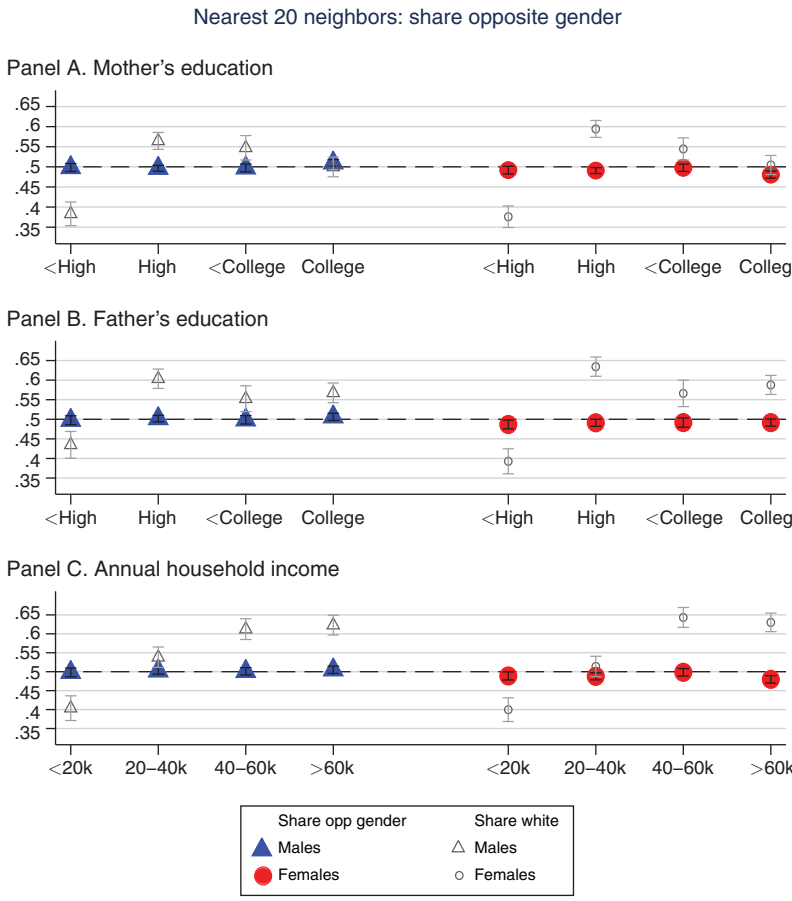

FIGURE 5. BALANCE TESTS

IV. Conclusion

This paper provides new evidence on the impact of the gender composition of school friends: an increase in the share of opposite gender school friends causes a reduction in high school academic achievement. Part of this effect seems to operate through changes in classroom behavior such as increased troubles getting along with the teacher and paying attention in class. Opposite gender school friends also increase the probability of being in a romantic relationship, which may be another mechanism for the negative effect on GPA given students in relationships may both substitute time away from studying and be distracted in the classroom.

These results speak to the continuing debate around single-sex and mixed gender education (Halpern et al. 2011; Pahlke, Hyde, and Allison 2014). Reorganizing classroom gender composition is a relatively low-cost policy as it need not require more teachers or resources. The difficulties getting along with the teacher and paying attention in class may be eliminated in single-sex classrooms that exclude opposite gender friends. The negative effects of opposite gender friends for younger students

are also found in mathematics and science and not in English and history, providing a dimension of empirical support for educators using single-sex mathematics and science classrooms in mixed gender schools.[35]

REFERENCES

Andrews, Donald W. K., and James H. Stock. 2005. "Inference with Weak Instruments." National Bureau of Economic Research (NBER) Technical Working Paper 313.

Angrist, Joshua D., and William N. Evans. 1998. "Children and Their Parents' Labor Supply: Evidence from Exogenous Variation in Family Size." *American Economic Review* 88 (3): 450–77.

Bertrand, Marianne, and Jessica Pan. 2013. "The Trouble with Boys: Social Influences and the Gender Gap in Disruptive Behavior." *American Economic Journal: Applied Economics* 5 (1): 32–64.

Bifulco, Robert, Jason M. Fletcher, and Stephen L. Ross. 2011. "The Effect of Classmate Characteristics on Post-secondary Outcomes: Evidence from the Add Health." *American Economic Journal: Economic Policy* 3 (1): 25–53.

Black, Sandra E., Paul J. Devereux, and Kjell G. Salvanes. 2013. "Under Pressure? The Effect of Peers on Outcomes of Young Adults." *Journal of Labor Economics* 31 (1): 119–53.

Booth, Alison L., Lina Cardona-Sosa, and Patrick Nolen. 2013. "Do Single-Sex Classes Affect Exam Scores? An Experiment in a Coeducational University." Institute for the Study of Labor (IZA) Discussion Paper 7207.

Bramoullé, Yann, Habiba Djebbari, and Bernard Fortin. 2009. "Identification of peer effects through social networks." *Journal of Econometrics* 150 (1): 41–55.

Buser, Thomas, Muriel Niederle, and Hessel Oosterbeek. 2012. "Gender, Competitiveness and Career Choices." National Bureau of Economic Research (NBER) Working Paper 18576.

Card, David, and Laura Giuliano. 2013. "Peer Effects and Multiple Equilibria in the Risky Behavior of Friends." *Review of Economics and Statistics* 95 (4): 1130–49.

Carrell, Scott E., and Mark L. Hoekstra. 2010. "Externalities in the Classroom: How Children Exposed to Domestic Violence Affect Everyone's Kids." *American Economic Journal: Applied Economics* 2 (1): 211–28.

Carrell, Scott E., Bruce I. Sacerdote, and James E. West. 2013. "From Natural Variation to Optimal Policy? The Importance of Endogenous Peer Group Formation." *Econometrica* 81 (3): 855–82.

Clark, Andrew E., and Youenn Lohéac. 2007. "'It wasn't me, it was them!' Social influence in risky behavior by adolescents." *Journal of Health Economics* 26 (4): 763–84.

Cooley, Jane. 2010. "Desegregation and the Achievement Gap: Do Diverse Peers Help?" http://www.ssc.wisc.edu/~jcooley/CooleyDeseg.pdf/.

Currarini, Sergio, Matthew Jackson, and Paolo Pin. 2009. "An Economic Model of Friendship: Homophily, Minorities, and Segregation." *Econometrica* 77 (4): 1003–45.

De Giorgi, Giacomo, Michele Pellizzari, and Silvia Redaelli. 2010. "Identification of Social Interactions through Partially Overlapping Peer Groups." *American Economic Journal: Applied Economics* 2 (2): 241–75.

Fletcher, Jason M., and Stephen L. Ross. 2012. "Estimating the Effects of Friendship Networks on Health Behaviors of Adolescents." National Bureau of Economic Research (NBER) Working Paper 18253.

Fletcher, Jason M., Stephen L. Ross, and Yuxiu Zhang. 2013. "The Determinants and Consequences of Friendship Composition." National Bureau of Economic Research (NBER) Working Paper 19215.

Foley, Kelly. 2012. "Can Neighbourhoods Change the Decisions of Youth on the Margins of University Participation?" *Canadian Journal of Economics* 45 (1): 167–88.

Fortin, Nicole M., Philip Oreopoulos, and Shelley Phipps. 2013. "Leaving Boys Behind: Gender Disparities in High Academic Achievement." National Bureau of Economic Research (NBER) Working Paper 19331.

Friesen, Jane, and Brian Krauth. 2011. "Ethnic Enclaves in the Classroom." *Labour Economics* 18 (5): 656–63.

Fuligni, Andrew J., and Harold W. Stevenson. 1995. "Time Use and Mathematics Achievement among American, Chinese, and Japanese High School Students." *Child Development* 66 (3): 830–42.

[35] According to the National Association for Single Sex Public Education (www.singlesexschools.org), the number of coeducational schools offering single-sex classrooms has increased from around a dozen in 2002 to 390 in the 2011-2012 school year.

Gager, Constance T., Teresa M. Cooney, and Kathleen Thiede Call. 1999. "The Effects Of Family Characteristics and Time Use On Teenage Girls' and Boys' Household Labor." *Journal of Marriage and Family* 61 (4): 982–94.

Gneezy, Uri, Muriel Niederle, and Aldo Rustichini. 2003. "Performance in Competitive Environments: Gender Differences." *Quarterly Journal of Economics* 118 (3): 1049–74.

Goodreau, Steven M., James A. Kitts, and Martina Morris. 2009. "Birds of a Feather, Or Friend of a Friend? Using Exponential Random Graph Models to Investigate Adolescent Social Networks." *Demography* 46 (1): 103–25.

Goux, Dominique, and Eric Maurin. 2007. "Close Neighbours Matter: Neighbourhood Effects on Early Performance at School." *Economic Journal* 117 (523): 1193–1215.

Granovetter, Mark S. 1973. "The Strength of Weak Ties." *American Journal of Sociology* 78 (6): 1360–80.

Gurian, Michael. 2010. *Boys and Girls Learn Differently! A Guide for Teachers and Parents.* San Francisco: Jossey-Bass.

Halpern, Carolyn Tucker, Kara Joyner, J. Richard Udry, and Chirayath Suchindran. 2000. "Smart Teens Don't Have Sex (Or Kiss Much Either)." *Journal of Adolescent Health* 26 (3): 213–25.

Halpern, Diane F., Lise Eliot, Rebecca S. Bigler, Richard A. Fabes, Laura D. Hanish, Janet Hyde, Lynn S. Liben, and Carol Lynn Martin. 2011. "The Pseudoscience of Single-Sex Schooling." *Science* 333 (6050): 1706–07.

Hanushek, Eric A., John F. Kain, and Steven G. Rivkin. 2009. "New Evidence about Brown v. Board of Education: The Complex Effects of School Racial Composition on Achievement." *Journal of Labor Economics* 27 (3): 349–83.

Hill, Andrew J. 2015. "The Girl Next Door: The Effect of Opposite Gender Friends on High School Achievement: Dataset." *American Economic Journal: Applied Economics.* http://dx.doi.org/10.1257/app.20140030.

Hoxby, Caroline. 2000. "Peer Effects in the Classroom: Learning from Gender and Race Variation." National Bureau of Economic Research (NBER) Working Paper 7867.

Jackson, C. Kirabo. 2012. "Single-sex schools, student achievement, and course selection: Evidence from rule-based student assignments in Trinidad and Tobago." *Journal of Public Economics* 96 (1–2): 173–87.

Ku, Hyejin, and Do Won Kwak. 2013. "Together or Separate: Disentangling the Effects of Single-Sex Schooling from the Effects of Single-Sex Schools." http://www.uq.edu.au/economics/abstract/487.pdf

Lavy, Victor, and Analía Schlosser. 2011. "Mechanisms and Impacts of Gender Peer Effects at School." *American Economic Journal: Applied Economics* 3 (4): 1–33.

Lavy, Victor, and Edith Sand. 2012. "The Friends Factor: How Students' Social Networks Affect Their Academic Achievement and Well-Being?" National Bureau of Economic Research (NBER) Working Paper 18430.

Lin, Xu. 2010. "Identifying Peer Effects in Student Academic Achievement by Spatial Autoregressive Models with Group Unobservables." *Journal of Labor Economics* 28 (4): 825–60.

Manski, Charles F. 1993. "Identification of Endogenous Social Effects: The Reflection Problem." *Review of Economic Studies* 60 (3): 531–42.

Moreira, Marcelo J., and Brian P. Poi. 2001. "Implementing Conditional Tests with Correct Size in the Simultaneous Equations Model." *Stata Journal* 1 (1): 1–15.

Mouw, Ted, and Barbara Entwisle. 2006. "Residential Segregation and Interracial Friendship in Schools." *American Journal of Sociology* 112 (2): 394–441.

Niederle, Muriel, and Lise Vesterlund. 2010. "Explaining the Gender Gap in Math Test Scores: The Role of Competition." *Journal of Economic Perspectives* 24 (2): 129–44.

Pahlke, Erin, Janet Shibley Hyde, and Carlie M. Allison. 2014. "The Effects of Single-Sex Compared With Coeducational Schooling on Students' Performance and Attitudes: A Meta-Analysis." *Psychological Bulletin* 140 (4): 1042–72.

Patacchini, Eleonora, Edoardo Rainone, and Yves Zenou. 2012. "Student Networks and Long-Run Educational Outcomes: The Strength of Strong Ties." http://people.su.se/~yvze0888/Patacchini_Rainone_Zenou_17_09_2012.pdf.

Poulin, François, Anne-Sophie Denault, and Sara Pedersen. 2011. "Longitudinal Associations Between Other-Sex Friendships and Substance Use in Adolescence." *Journal of Research on Adolescence* 21 (4): 776–88.

Sabia, Joseph J. 2007. "Reading, Writing, and Sex: The Effect of Losing Virginity on Academic Performance." *Economic Inquiry* 45 (4): 647–70.

Sacerdote, Bruce. 2001. "Peer Effects with Random Assignment: Results for Dartmouth Roommates." *Quarterly Journal of Economics* 16 (2): 681–704.

Schneeweis, Nicole, and Martina Zweimüller. 2012. "Girls, girls, girls: Gender composition and female school choice." *Economics of Education Review* 31 (4): 482–500.

Smith, Jonathan. 2013. "Peers, Pressure, and Performance at the National Spelling Bee." *Journal of Human Resources* 48 (2): 265–85.

Stinebrickner, Ralph, and Todd R. Stinebrickner. 2006. "What can be learned about peer effects using college roommates? Evidence from new survey data and students from disadvantaged backgrounds." *Journal of Public Economics* 90 (8–9): 1435–54.

Stock, James H., Jonathan H. Wright, and Motohiro Yogo. 2002. "A Survey of Weak Instruments and Weak Identification in Generalized Method of Moments." *Journal of Business and Economic Statistics* 20 (4): 518–29.

Waddell, Glen R. 2012. "Gender and the influence of peer alcohol consumption on adolescent sexual activity." *Economic Inquiry* 50 (1): 248–63.

Whitmore, Diane. 2005. "Resource and Peer Impacts on Girls' Academic Achievement: Evidence from a Randomized Experiment." *American Economic Review* 95 (2): 199–203.

Zimmerman, D. J. 2003. "Peer Effects in Academic Outcomes: Evidence from a Natural Experiment." *Review of Economics and Statistics* 85 (1): 9–23.