Friendship Formation by Race and Achievement: Implications on Racial Gaps in Friends and Earnings

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Abstract

This paper investigates adolescent friendship formation, focusing on race and academic achievement. Using dyadic regression and social network data of students from Add Health, we demonstrate that students tend to form friendships within their racial group and with similar GPAs. We further find comparable sensitivities to GPA differences between Black and White student pairs, with less pronounced sensitivities in cross-racial friendships. Through counterfactual analysis using regression coefficients and GPA distributions, we present that fewer friendships observed among high-achieving Black students, in comparison to their White peers, are attributed to the scarcity of high-achieving Black students. Our estimations suggest that this disparity in friendships among high-achieving Black students significantly contributes to the earnings gap between Black and White individuals.

JEL: I21, J15

Keywords: social networks, friendship formation, homophily, racial friends gap, racial earnings gap

1 Introduction

Friendship within the school environment is paramount. A growing body of literature underscores the impact of school peers on various aspects, including academic performance, choice of field of study, future earnings, and engagement in risky behavior (Anelli and Peri 2019; Bifulco, Fletcher, and Ross 2011; Calvó-Armengol, Patacchini, and Zenou 2009; Carrell, Hoekstra, and Kuka 2018; Imberman, Kugler, and Sacerdote 2012; Nakajima 2007). Recent works by Chetty et al. (2022a, 2022b) even find that friendship plays a crucial role in shaping economic mobility and inequality, emphasizing connecting with peers from higher socioeconomic backgrounds increases the likelihood of upward mobility.

However, segregation based on socioeconomic status and race acts as a barrier, limiting minority children's access to peers from higher socioeconomic status (Ananat 2011; Angrist and Lang 2004; Cutler and Glaeser 1997). Even in areas with less segregation, a noticeable "friending bias" persists, wherein individuals tend to form friendships with others from the same race and socioeconomic class (Mayer and Puller 2008; McPherson, Smith-Lovin, and Cook 2001; Mele 2020). These dynamics contribute to the perpetuation of socioeconomic disparities despite efforts towards desegregation.

Fig. 1. Number of Friends by GPA
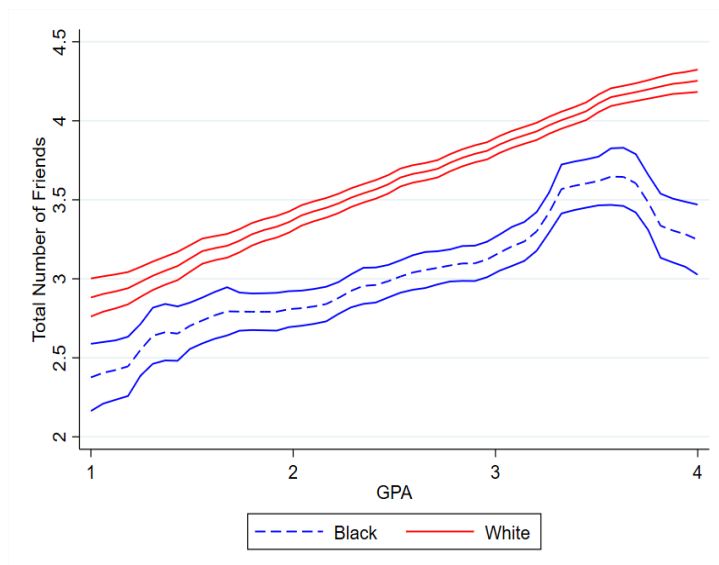
Notes. The figure depicts the average number of friends across GPA distribution separately by Black and White students. We use Black and White students in the in-school survey of the National Longitudinal Study of Adolescent to Adult Health.

The disparity extends beyond the traits of friendships (Currarini, Jackson, and Pin 2010; Marsden 1987). As depicted in Figure 1, minority students, particularly those who excel academically, often have fewer friends, with some attributing this phenomenon to evidence of oppositional culture (Fryer Jr and Torelli 2010). Considering the importance of the number of friendships (Lleras-Muney et al. 2020), the disadvantage is further exacerbated among minority students, alongside differences in the characteristics of friendships they form, even before they enter the labor market. Consequently, comprehending the factors influencing friendship formation and the roots of disparities in friendships among different groups is crucial in gaining insights into human development, economic mobility, and inequality.

We study why the racial gap in the number of friendships arises particularly for high-achievers and its implications on later labor market outcomes. We first construct a framework of friendship formation, taking into account academic achievement and race. Specifically, we investigate how differences in academic achievement interact with races of students in the formation of friendships, using dyadic regression and the social network data of students from the National Longitudinal Study of Adolescent to Adult Health (Add Health). Based on the constructed framework, we explore the reasons for the racial gap in friendships and the types of friends they form. We further find implications for the racial earnings gap.

We find pronounced homophily in academic achievement, in line with previous studies (Flashman 2012a; Smirnov and Thurner 2017). An increase of one unit in GPA difference between pairs of students corresponds to a 0.164 percentage point decrease in the likelihood of friendship formation within the school when the overall mean is 0.694 percent. Notably, the relationship between GPA disparity and friendship formation is more prominent among individuals of the same race than those of different racial backgrounds. Specifically, Black-Black and White-White pairs exhibit a decrease in the likelihood of friendship formation by 0.172 and 0.189 percentage points, respectively. In contrast, Black-White pairs are 0.031 percentage points less likely to form friendships with each one-unit increase in GPA difference.

Moreover, our results highlight a strong tendency toward homophily in terms of race, consistent with earlier research (Currarini, Jackson, and Pin 2009; Mele 2020). The probabilities of friendship formation are 1.11 percent for Black-Black pairs and 0.86 percent for White-White

pairs when the GPAs are equal. In contrast, the probability of friendship formation is lower, at 0.24 percent, for Black-White pairs. These findings underscore the importance of academic achievement and racial homophily in the formation of friendships within the school context.

We explore heterogeneity in friendship formation across schools with different racial compositions. Notably, our observations indicate that high-achieving Black students tend to have fewer friends than their White counterparts only in schools where Black students are in the minority. Nevertheless, our dyadic regression analysis reveals consistent patterns across schools with diverse racial compositions while Black-Black pairs in Black majority schools are relatively less sensitive to achievement disparities in friendship formations.

Drawing from the findings, we delve into the underlying factors contributing to the racial disparity in the number of friends. One existing explanation for this gap is the phenomenon known as "acting White" (Fryer Jr and Torelli 2010), which suggests that high-achieving minority students may face social ostracization from their peers—a topic extensively explored in anthropology and sociology literature (Austen-Smith and Fryer Jr 2005; Fordham and Ogbu 1986). However, by conducting counterfactual analysis using the estimated coefficients from our dyadic regression and GPA distributions of Black and White students, we find that the fewer friendships of high-achieving Black students are attributed to limited exposure to high-achieving Black students and strong racial homophily.

Specifically in our counterfactual analysis, we begin by simulating the expected number of high- and low-achieving friends by race and GPA. The simulation results closely resemble the actual data both quantitatively and qualitatively. Using the simulation results, we investigate how the racial gap in friends changes for high-achieving students relative to those with the lowest GPA. We first equalize the proportion of Black and White students in school (level effects), and then equalize the GPA distribution of Black students with that of White students (composition effect). Through our counterfactual analyses incorporating both level and composition effects, we observe changes in the friendship gap (White - Black) of high-achieving students from 1.05 to 0.07 for high-achieving friends and from -0.26 to -0.15 for low-achieving friends. Thus, under the equal proportion and GPA distribution, the gap in friends for high-achieving students would decrease by 0.87 in total.

Lastly, we assess the extent to which the Black-White earnings gap can be attributed to the difference in the number of friends. Our analysis includes a sample primarily comprising individuals in their early twenties, with an average annual income of \$36,000. After adjusting for demographic factors and individual skills, Black individuals exhibit 22.4% lower yearly earnings compared to White counterparts. Using instrumental variable analysis (Lleras-Muney et al. 2020), we find that one more friend increases yearly earnings by 12.4 percent. Considering our estimated reduction in the expected friendship gap in counterfactual scenarios (0.87 friends) and the estimated causal impact of one more friend on earnings (12.4% more annual earnings), the wage gap is expected to decrease in our counterfactual scenario from 22.4% to 14.0%, representing a reduction of the gap by 8.4 percentage points (38%). Notably, each additional high-achieving friend correlates with a 2.9% increase in earnings, whereas the impact of adding a low-achieving friend is 1.2%, which suggests our estimate for a reduced earnings gap might be underestimated.

In this paper, we contribute to strands of the literature in economics. First, we contribute to the literature on the disparities in friendships among different demographic groups and more broadly on homophily in social networks. Extensive research has examined homophily across various dimensions, such as race and socio-economic status (Mayer and Puller 2008; McPherson, Smith-Lovin, and Cook 2001; Mele 2020), which poses additional hurdles for minorities and individuals from low socioeconomic backgrounds (Chetty et al. 2022b). Moreover, Currarini, Jackson, and Pin (2009) highlight that minority groups, in general, tend to have fewer connections. Building upon this, our study presents how homophily based on race and academic achievement, when coupled with the distribution of major and minor students, results in fewer friendships for high-achieving minorities.

Our paper also contributes to the literature on the influence of peer pressure on youth's behavior (Bursztyn, Egorov, and Jensen 2019; Bursztyn and Jensen 2015; Coleman 1961). Particularly, Austen-Smith and Fryer Jr (2005) and Eguia (2017) theorize the phenomenon of acting White—high performance Black induces peer group rejection. The empirical evidence presented by Fryer Jr and Torelli (2010) supports it by indicating that high-achieving Black students tend to have fewer friends compared to their White counterparts. Contrary to this perspective, Andrews

and Swinton (2014) find limited evidence supporting the idea that Black students experience more substantial peer rejections based on academic achievement. Research in sociology also challenges the oppositional culture framework (Tyson and Lewis 2021), presenting that Black students are equally achievement-oriented as their White students (Diamond and Huguley 2014; Flashman 2012b; Hanselman et al. 2014). We contribute to the literature by demonstrating that the seemingly oppositional culture—manifested as a lower number of friends for high-achieving Black students—is specifically observed in Black minority schools and that this phenomenon can be explained by two factors: the racial composition and GPA distribution of Black and White students.

Lastly, we contribute to the literature on the racial earnings gap (Altonji and Blank 1999; Bayer and Charles 2018; Brown 1984; Juhn, Murphy, and Pierce 1993; Lang and Lehmann 2012; Neal and Johnson 1996), particularly due to the peers and social network (Arrow and Borzekowski 2004; Calvó-Armengol and Jackson 2004; Holzer 1987). We demonstrate that high-achieving black students structurally tend to have fewer friends due to the smaller proportion in schools, lower average GPA, and homophily in friendship formation. Building upon the findings of Lleras-Muney et al. (2020) regarding the influence of friendship networks on earnings, we highlight the substantial role of racial difference in friendship to the racial earning gap. To our knowledge, this paper is the first to quantify the significance of the racial disparity in friendship networks in secondary schools in understanding earning disparities between racial groups.

The remainder of this paper proceeds as follows. In Section 2, we describe the dataset in detail. Section 3 describes the dyadic regression and presents empirical outcomes. In Section 4, we explore the implications on Black and White gaps in friendships and earnings by performing counterfactual exercises. We conclude in Section 5.

2   Data

The National Longitudinal Study of Adolescent to Adult Health (Add Health) is a nationally representative sample of adolescents in grades 7-12 during the 1994-1995 school year (Wave I). The survey consists of in-school data and in-home survey data. We use the in-school data for our analysis of friendship formation, which consists of a sample of 90,118 students. We restrict

our sample to students who reported GPA and demographic variables including race, age, and sex. To understand the Black-White friendship formation difference, we focus on non-Hispanic Black and non-Hispanic White students.[1]

Fig. 2. GPA Distribution by Race and Achievement
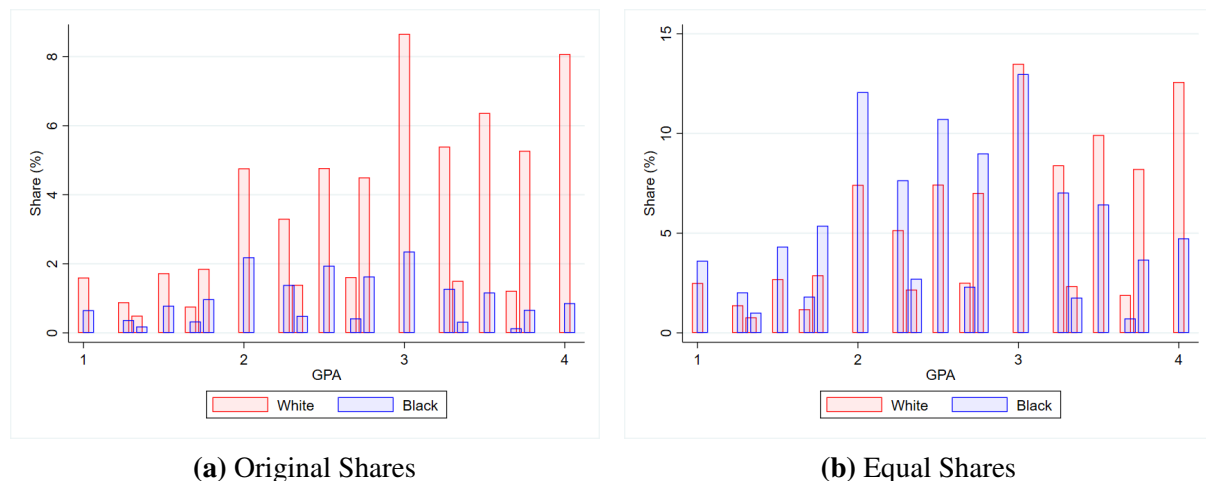
(a) Original Shares   **(b)** Equal Shares

Notes. The figures illustrate the distributions of average GPA for Black and White students. The red bar indicates the density of the average GPA of White students. The blue bar indicates the density of the average GPA of Black students. We use Black and White students in the in-school data of the National Longitudinal Study of Adolescent to Adult Health. The sub-figure (a) illustrates the average GPA distribution with original Black and White shares. The sub-figure (b) illustrates the average GPA distribution after equalizing Black and White shares.

In Figure 2 (a), we show the GPA distribution based on the original data. We calculate the average GPA based on English, math, history, and science as a measure of achievement. The GPA scale ranges from 1 to 4. We find that White students comprise of the majority of the sample, accounting for 78.9 percent of the total, while Black students constitute 21.1 percent. Moving on to sub-figure (b), we equalize the proportion of Black and White students to facilitate a direct comparison of GPA distributions between the two racial groups. Our findings reveal that White students are more likely to have higher GPA, while Black students tend to be more concentrated in the middle range of the GPA distribution. Specifically, the average GPA of White students is 2.9, which is higher than that of Black students, which stands at 2.6.

The in-school data collect information on the social network of each participant. The survey asks students to list up to five male and five female friends. In this study, we define friendship as a binary variable, taking one when an individual has been nominated as a friend by another

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[1] See Table A.1 for summary statistics at the individual level.

within the same school.[2]

To analyze the distribution of friendship formation and GPA differences at the pairwise level, we generate all possible pairs of students within each school and match their individual-level characteristics. It is important to note that the pairs are directional. The friendship measure represents a friendship nomination from student i to student j. For instance, student i can nominate student j as a friend, but it does not necessarily mean that the nomination is reciprocated or that student j will nominate student i as a friend.

From the pool of potential pairs of students within each school, we categorize them into four groups based on the racial composition: White-White, Black-Black, White-Black, and Black-White. In total, we have 141 schools, with an average of 395 Black or White students per school. Consequently, the overall number of potential pairs amounts to 36,183,256.

Table 1: Summary, Pairwise Level

	White→White	Black→Black	White→Black	Black→White	All
Friend (%)	0.567	0.784	0.125	0.103	0.513
GPA diff.	0.9	0.8	0.9	0.9	0.9
Share (%)	73.29	9.91	8.40	8.40	100
Observations	26,517,518	3,584,014	3,040,862	3,040,862	36,183,256

Notes. The total number of observations is 36,183,256, which is all potential pairs of students. This is based on the 54,613 non-Hispanic Black and non-Hispanic White students who reported GPA and individual characteristics (age, gender, and race) from the in-school survey of the National Longitudinal Study of Adolescent to Adult Health. Friend(%) measures the shares of friendship formation out of all potential pairs of students. If student i nominates student j as a friend but j does not, we define $i - j$ pair as friends but not the pair $j - i$. GPA difference measures the average difference in GPA between pairs.

Table 1 provides summary statistics at the pairwise level. Firstly, it reveals that White-White pairs constitute 73.29 percent of all potential pairs among White or Black students. Black-Black pairs account for 9.91 percent, while both White-Black and Black-White pairs represent 8.40 percent each. The average rate of friendship formation across all potential pairs is 0.51 percent. This means that out of all possible pairs of students, 0.51 percent result in the formation of friendships. Black-Black pairs exhibit a higher friendship formation rate at 0.78 percent, while White-White pairs have a slightly lower rate of 0.57 percent. Friendship formation rates between

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[2] Students can list their friends up to five male friends and five female friends. While a student can list up to ten friends as the "sender", the friendship measure we utilize is based on the number of "receiving" nominations. For instance, if there are 400 students in a particular school, the maximum number of friendship nominations that one student can receive is 399, as they cannot nominate themselves.

students of different races are lower than those within the same racial group, with rates of 0.10 percent for Black-White pairs and 0.13 percent for White-Black pairs. Lastly, there is no significant difference between groups in terms of GPA differences between pairs. The average GPA difference for all possible Black-Black pairs is 0.8, whereas for the other types of pairs, it is 0.9.

3 Friendship Formation

3.1 Empirical Strategy

We focus on analyzing patterns in the formation of friendships, with a specific emphasis on the role of race, achievement, and the interaction between the two. By studying the interaction, we explore whether the importance of differences in achievement varies based on the race of two students involved in forming a friendship.

In our analysis, we treat each potential dyad of students within each school as an individual observation. This dyadic approach enables us to examine how the probability of forming friendships differs across racial pairs and how it changes as the difference in achievement increases between the two students.

In Figure 3, we examine the matching patterns based on race and achievement. The figure illustrates how the proportion of dyads forming friendships varies by the difference in achievement and race pairs (Black-Black, White-White, or Black-White or White-Black).[3] A few patterns are worth noting. First, same-race pairs are more likely to form friendships. For instance, approximately 0.9 percent of dyads consisting of both Black students with identical GPAs become friends. Similarly, approximately 0.75 percent of dyads composed of both White students with identical GPAs end up as friends. On the other hand, approximately 0.2 percent of dyads consisting of students from different races (Black-White or White-Black) with identical GPAs end up as friends. Secondly, the probability of friendship formation notably declines as the difference in GPA increases. This declining trend is consistent between White-White and Black-Black pairs. In other words, GPA differences in friendship formation matter similarly

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[3] Appendix A.2 provides a detailed explanation of our methodology for calculating the likelihood of friendship formation, accompanied by an illustrative example.

Fig. 3. Probability of Forming Friendships by GPA difference and race
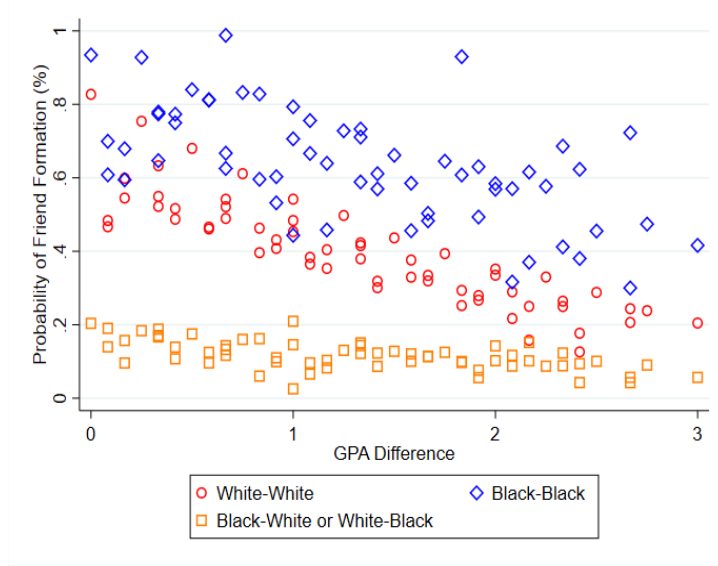
Notes. The figure illustrates probability of forming friendships based on the GPA difference between pairs, depicted separately for racial combinations. We use Black and White students in the in-school survey of the National Longitudinal Study of Adolescent to Adult Health. Each potential dyad of students in each school is treated as an observation.

between White-White and Black-Black pairs of students. Conversely, the difference in GPA has less significance in the formation of friendships across different races compared to the formation within the same race.

We adopt a dyadic regression to estimate the formation of friendships among adolescent students based on race and achievement. We construct a matrix that includes all possible friendship dyads, considering both sender and receiver pairs within each school. For each school, s, we observe a total of N_s students. This results in a dataset with potential pairs $\sum_{s=1}^{141} N_s \times (N_s - 1)$. The regression equation takes the following form:

$$G_{ij} = \alpha_0 + \beta_0 d_{ij} + \beta_{bb} d_{ij} \times B_i B_j + \beta_{bw} d_{ij} \times B_i W_j + \beta_{wb} d_{ij} \times W_i B_j$$

$$+ \alpha_{bb} B_i B_j + \alpha_{bw} B_i W_j + \alpha_{wb} W_i B_j + X_{ij} \Gamma + \lambda_s + \varepsilon_{ij} \tag{1}$$

where G_{ij} is an indicator variable that takes the value of one if student i designates student j as a friend. The variable d_{ij} represents the difference in achievement (GPA) between students i and j expressed as absolute values. The analysis includes two racial categories: Black and White, denoted by B and W respectively. The directional links between students can be categorized

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into four types: B_iB_j, B_iW_j, W_iB_j, and W_iW_j. For instance, the indicator B_iW_j indicates that student i (the friendship sender) is Black and student j (the friendship receiver) is White. The omitted category in the analysis is White-White pairs of students. The vector X_{ij} incorporates a set of control variables at the dyad-level, such as the difference in ages and gender pairs, and individual level, including gender, age, and average GPA of senders and receivers. We also include school fixed effects, λ_s. We cluster the standard errors at the school level to account for potential dependence within schools.[4]

As Equation (1) excludes White pairs of students, the parameter α_0 represents the baseline probability of friendship formation for White pairs. The remaining parameters in the α group, namely α_{bb}, α_{bw}, and α_{wb}, capture the deviation in the probability of forming friendships for the respective race pairs (Black-Black, Black-White, and White-Black) compared to the baseline probability of White pairs. Regarding the β parameters, β_0 captures the extent to which differences in achievement matter for White students. If β_0 is negative, it means that White students are less likely to list other White students as friends as the difference in achievement increases. β_{bb} captures how much differences in achievement matter differently for Black students listing Black students as friends, compared to White students listing White students. If the differences in achievement matter less for across-race friendship than within-race friendship, the parameters β_{bw} and β_{wb} will be positive. Additionally, if there is a race asymmetry in how differences in achievement matter for friendship formation, the values of β_{bw} and β_{wb} will differ.

3.2 Results

3.2.1 Friendship Formation by GPA and Race

Table 2 presents the results of the estimation of Equation (1). In column (1), we find that as the difference in achievements (measured by GPA) between two students increases, the likelihood of forming friendships decreases.[5] Specifically, for each one-unit increase in GPA difference, the

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[4] Our regression analysis assumes that each student in the school has an equal probability to encounter and potentially form a friendship with any other students. Under this assumption, the coefficients in the regression model represent the preference parameters associated with the characteristics of both the sender (i) and the receiver (j), as well as the disparities in their characteristics. However, one might have a concern with the assumption of equal probability. To alleviate the concern, we conduct the same analysis among students within the same school club and find consistent results with our baseline results. See Appendix A.5 for more details.

[5] One might be concerned about endogeneity using GPA as a performance measure affecting friendship since GPA could be affected by the friendship formation. To alleviate the concerns, we alternatively use the mother's

likelihood of friendship formation in the school decreases by 0.189 percentage points compared to the overall mean of 0.513 percent. The constant term represents the probability of friendship formation when there is no difference in GPA between students. In column (2), we further control for demographic variables, such as the genders and ages of the senders and receivers, as well as dyad-level control variables including the difference in ages and gender pairs, and school fixed effects. The coefficient remains similar. Specifically, the analysis shows that the probability of friendship formation decreases by 0.164 percentage points for each one-unit increase in GPA difference. These findings suggest a negative relationship between the difference in achievement and the likelihood of forming friendships, even after considering various controls.

In columns (3) and (4), we examine whether the difference in achievement has a varying association with friendship formation for pairs of Black students, pairs of White students, and pairs of Black and White students. We investigate this association both without additional covariates (column 3) and with the inclusion of other covariates (column 4). The results indicate that regardless of whether the covariates are controlled for or not, the difference in GPA has a similar relationship to friendship formation for pairs of Black students and pairs of White students. When GPA gap increases by 1 for White students, they are 0.189 percentage points less likely to form friendships. Compared to White race pairs, the difference in GPA matters less for Black pairs of students although the coefficient is statistically insignificant. That is, the difference in GPA for Black students is similar to that of White students.[6]

Moreover, we examine the significance of achievement differences across different races in friendship formation, as indicated by the rows of $dGPA \times BW$ and $dGPA \times WB$. The results suggest that the influence of GPA differences on friendship formation is weaker for pairs of different races compared to pairs within the same race. Specifically, Black-White pairs are 0.031 percentage points less likely to form friendships when the GPA difference increases by 1, and White-Black pairs are 0.032 percentage points less likely.

We find that within-race friendships are more prevalent compared to across-race friendships,

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education as a measure of achievement and find qualitatively similar results. See Appendix A.3 for more details.

[6] It is important to note that we compare the racial groups on a percentage points level. Given that Black pairs exhibit a higher baseline probability of friendship formation, comparable percentage points indicates that Black pairs are less concerned about GPA differences. However, we focus on the percentage points level comparison as our primary interest lies in the actual number of friends formed.

Table 2: Friendship Formation by Race and Achievement

	(1)	(2)	(3)	(4)	(5)
			Dependent variable : i denoting j as a friend (%)		
dGPA	-0.189***	-0.164***	-0.216***	-0.189***	-0.259***
	(0.019)	(0.015)	(0.025)	(0.022)	(0.028)
dGPA × BB			0.047	0.017	0.038
			(0.044)	(0.045)	(0.049)
dGPA × BW			0.188***	0.158***	0.200***
			(0.025)	(0.022)	(0.025)
dGPA × WB			0.182***	0.158***	0.193***
			(0.024)	(0.023)	(0.026)
BB			0.168	0.250	
			(0.166)	(0.171)	
BW			-0.624***	-0.627***	
			(0.078)	(0.061)	
WB			-0.597***	-0.603***	
			(0.078)	(0.060)	
Constant	0.674***	0.694***	0.752***	0.862***	0.938***
	(0.060)	(0.097)	(0.080)	(0.129)	(0.051)
Observations	36,183,256	36,183,256	36,183,256	36,183,256	36,183,256
Mean	0.513	0.513	0.513	0.513	0.513
Controls		X		X	X
Individual FE					X

Notes. The table presents coefficients and standard errors from estimation of equation (1). Units of observation are directed dyads, based on the non-Hispanic Black and non-Hispanic White students who reported GPAs and individual characteristics (age, gender, and race) from the in-school survey of the National Longitudinal Study of Adolescent to Adult Health. The dependent variable takes on the value of 1 if student i nominated student j as a friend. *dGPA* indicates a difference in average GPA between the pairs of students. *B* indicates a Black student and *W* indicates a White student. *BW* is an indicator that the sender is a Black student and the receiver is a White student. Mean is the average probability of forming friendships. Controls indicates the controlling demographic variables including gender and age of senders and receivers, difference in ages between pairs, and school fixed effects. Individual FE indicates controlling for individual fixed effects of senders and receivers. *** $p < .01$, ** $p < .05$, * $p < .1$

which align with the concept of racial segregation (e.g., Currarini, Jackson, and Pin 2009; Marmaros and Sacerdote 2006). The baseline probability of forming friendships between Black-Black pairs is approximately 1.11 percent, while that of White-White pairs is 0.86 percent. In contrast, the baseline probability of friendship formation across different races is much lower, ranging from 0.235 to 0.259 percent. The findings highlight the presence of racial homophily in friendship formation, where individuals tend to form friendships more frequently with others of the same race than with individuals of different races.

In column (5), we present the estimation results with individual fixed effects for both

friendship senders and receivers. This accounts for the correlation between race and the possibility that certain students may be more likely to consider others as friends, and some students may be more popular within the school. Despite controlling for these fixed effects, the estimated coefficients remain qualitatively similar.
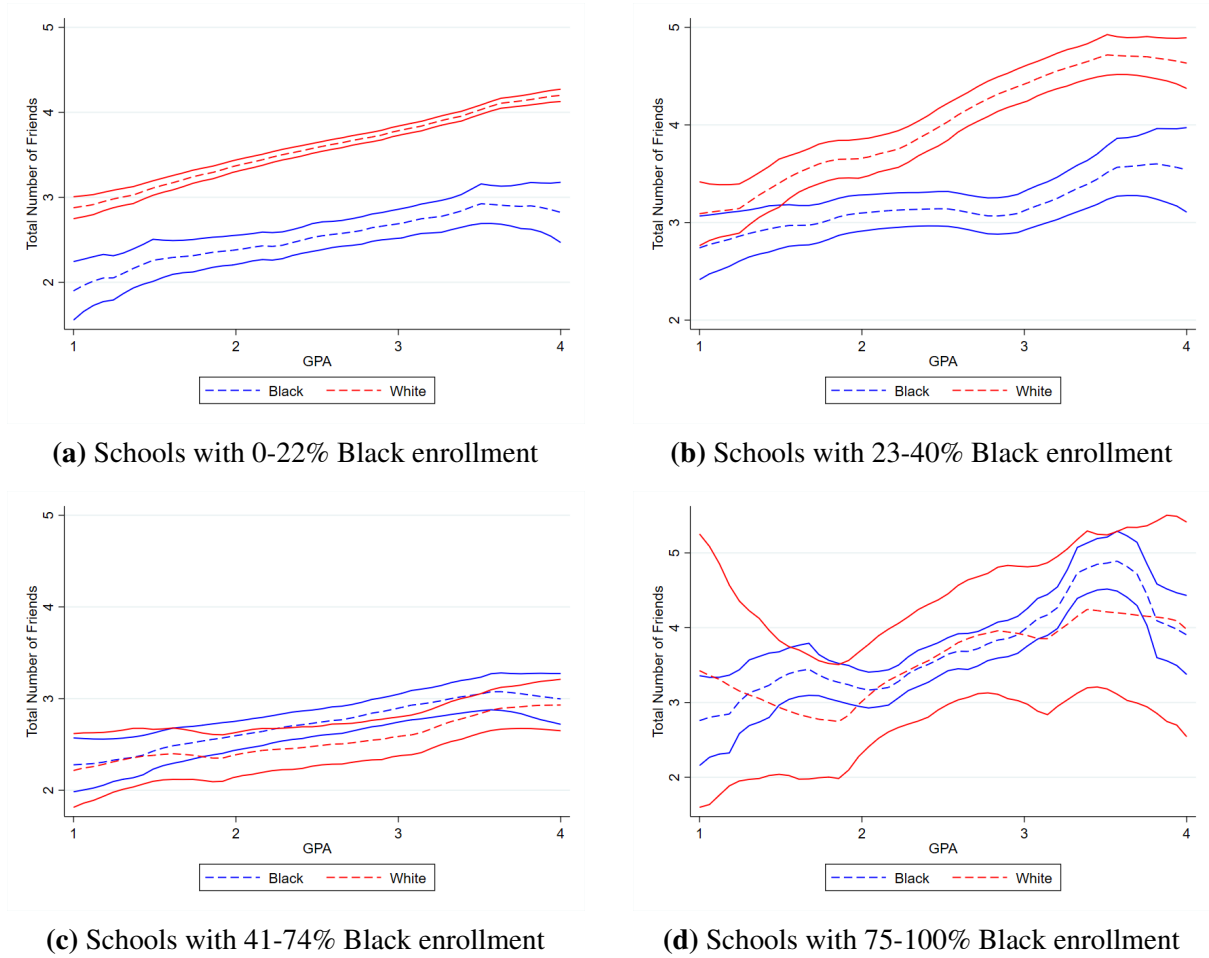
The aforementioned findings are robust across various alternative specifications, as detailed in the Appendix. These alternative specifications include: (i) using the mother's education as a performance measure (Appendix A.3); (ii) comparing students within the same extracurricular activities (Appendix A.5); (iii) using mutual friendships instead of one side friendship nominations (Appendix B.1); (iv) accounting for asymmetry of GPA between low-high and high-low friendship nominations (Appendix B.2); (v) using semiparameteric GPA measures as low and high (Appendix B.3); and (vi) including Hispanic students in the sample (Appendix B.4). Across all these alternative specifications, the main findings regarding the relationship between GPA differences and friendship formation for race pairs remain consistent.

3.2.2 Heterogeneity Across Black Shares in Schools

In this subsection, we explore heterogeneity in friendship formation across schools with different racial compositions. The share of Black students in a school can affect the likelihood of meeting students of the same race (Currarini, Jackson, and Pin 2009). It may also modify the relationship between race and achievement in forming friendships. We divide schools into four groups as each group has the same number of black students: the first, second, third, and fourth groups include schools with Black student shares ranging from 0% to 22%, 23% to 40%, 41% to 74%, and 75% to 100%, respectively.

In Figure 4, we first present the number of friends, categorized by race and the share of Black students. A few patterns are worth noting. High-achieving Black students in Black minority schools (0-40%) tend to have significantly fewer friends than their White peers, whereas this disparity is absent in schools where the Black population is not a minority (41-100%). Low-achieving Black students in Black minority schools also exhibit differences in the number of friends compared to their White counterparts although the difference is smaller than high-achieving students. Moreover, we present the GPA distribution of Black and White students by the proportion of Black students in Figure A.3. While White students tend to cluster above a

Fig. 4. Number of Friends by GPA and Black Students Proportion of Schools

(a) Schools with 0-22% Black enrollment

(b) Schools with 23-40% Black enrollment

(c) Schools with 41-74% Black enrollment

(d) Schools with 75-100% Black enrollment

Notes. The figure depicts the locally smoothed means of the number of friends across GPA distribution, categorized by race and the share of Black students. We use Black and White students in the in-school survey of the National Longitudinal Study of Adolescent to Adult Health.

GPA of 3 and Black students are concentrated between 2 and 3, Black minority schools show more pronounced differences in the distribution of GPA.[7] In essence, the figure suggests that high-achieving Black students tend to have a smaller circle of friends compared to their White peers, especially in schools where the proportion of Black students is smaller, particularly at higher GPA.

Table 3: Friendship Formation by Race and Achievement: Across Black Student Proportion

	Dependent variable : Probability of i denoting j as a friend (%)				
	(1) All	(2) 0-22%	(3) 23-40%	(4) 41-74%	(5) 75-100%
$dGPA$	-0.189***	-0.179***	-0.284***	-0.267***	-1.361***
	(0.022)	(0.022)	(0.062)	(0.032)	(0.116)
$dGPA \times BB$	0.017	-0.095	0.044	0.187***	1.152***
	(0.045)	(0.075)	(0.032)	(0.032)	(0.127)
$dGPA \times BW$	0.158***	0.144***	0.267***	0.239***	1.317***
	(0.022)	(0.022)	(0.061)	(0.040)	(0.106)
$dGPA \times WB$	0.158***	0.145***	0.265***	0.245***	1.322***
	(0.023)	(0.022)	(0.063)	(0.034)	(0.098)
BB	0.250	1.212***	0.300**	-0.513***	-5.207***
	(0.171)	(0.285)	(0.128)	(0.122)	(0.186)
BW	-0.627***	-0.474***	-1.000***	-0.983***	-5.927***
	(0.061)	(0.048)	(0.208)	(0.144)	(0.223)
WB	-0.603***	-0.448***	-0.987***	-0.952***	-5.838***
	(0.060)	(0.047)	(0.213)	(0.128)	(0.259)
Constant	0.862***	0.741***	0.935***	1.701***	6.103***
	(0.129)	(0.098)	(0.276)	(0.244)	(0.301)
Observations	36,183,256	26,910,900	4,993,870	2,743,852	1,534,634
Mean	0.513	0.509	0.539	0.400	0.686
Controls	X	X	X	X	X

Notes. Notes. The table presents coefficients and standard errors from estimation of equation (1), separately by the share of Black students. Units of observation are directed dyads, based on non-Hispanic Black and non-Hispanic White students who reported GPAs and individual characteristics (age, gender, and race) from the in-school survey of the National Longitudinal Study of Adolescent to Adult Health. The dependent variable takes on the value of 1 if student i nominated student j as a friend. *dGPA* indicates a difference in average GPA between the pairs of students. *B* indicates Black students, and *W* indicates White students. The schools are divided into four quantile groups as follows: the first quantile (Q1) includes schools with Black student shares ranging from 0% to 22%; the second quantile (Q2) includes schools with Black student shares between 23% and 40%; the third quantile (Q3) includes schools with Black student shares between 41% and 74%; and the fourth quantile (Q4) includes schools with Black student shares between 75% and 100%. *** $p < .01$, ** $p < .05$, * $p < .1$

In Table 3, we estimate Equation (1) separately for students enrolled in schools with different

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[7] Specifically, in schools with Black student shares ranging from 0%-22%, 23%-40%, 41%-74%, and 75%-100%, the gaps in shares with GPA 3-4 between Black and White students are 19%, 19%, 13%, and 1% respectively.

shares of Black students. This analysis enables us to explore how friendship formation patterns vary across different levels by the share of Black students in schools. We present the estimation results starting with all schools in column (1), followed by schools categorized based on different shares of Black students in columns (2) to (5).

Across all types of schools, we observe that the significance of GPA differences is either similar or less pronounced for Black students compared to White students. Specifically, in columns (2) and (3), we find no significant relationship between $dGPA \times BB$ (difference in GPA multiplied by an indicator for Black students) and friendship formation in schools where White students are in the majority. However, positive results are observed for schools with a Black student share exceeding 40%. Notably, we find that the degree of overall racial homophily, denoted as BB, is contingent upon the proportion of Black students. Specifically, as the share of Black students increases, the corresponding coefficient diminishes. In Table A.5, we find similar results while controlling friendship senders' and friendship receivers' fixed effects.

4   Implications on the Black and White Gaps in Friends and Earnings

In this section, we conduct simulations to analyze potential shifts in the number of friendships among Black students relative to White students. We equalize the proportions in school and the distributions of GPA for Black and White students to investigate the reasons and mechanisms behind the phenomenon of high-achieving Black students having fewer friends than their White counterparts. To account for the difference in friends, we categorize friends into two groups based on their GPA: those with GPA ranging from 1 to 3 (considered low-achieving friends) and those with GPA ranging from 3 to 4 (considered high-achieving friends). Moreover, we estimate equation (1) to each school separately, using school-specific coefficients to isolate the unique characteristics of each school in the analysis process.

Based on the estimated parameters in Equation (1) and the GPA distributions by race, we first calculate the simulated total number of friendships received for student j who is Black and

GPA of x using the following equation:

$$\sum_{s \in E} N_B^s \times \int_{lb}^{ub} \left[(\alpha_0^s + \alpha_{BB}^s) + (\beta_0^s + \beta_{BB}^s)|x - z| \right] f_B^s dz$$

$$+ \sum_{s \in E} N_W^s \times \int_{lb}^{ub} \left[(\alpha_0^s + \alpha_{BW}^s) + (\beta_0^s + \beta_{BW}^s)|x - z| \right] f_W^s dz \qquad (2)$$

where for each school s, N_B^s is the number of Black students, and N_W^s is the number of White students. $f_B^s(z)$ is the GPA distribution for Black students in school s, and $f_W^s(z)$ is the GPA distribution for White students. α^s and β^s are the estimated parameters from Equation (1) that capture the baseline probability of forming friendships (α_0^s) and its deviation in the probability (α_{BB}^s and α_{WB}^s), and the interaction between GPA and race for the respective race pair (β_0^s, β_{BB}^s, and β_{WB}^s). E represents the set of schools that contains all coefficients of α^s and β^s. For low-achieving friends, lb and ub are designated as 1 and 3, respectively, while for high-achieving friends, lb and ub are set to 3 and 4.

The term $(\alpha_0^s + \alpha_{BB}^s) + (\beta_0^s + \beta_{BB}^s)|x - z|$ represents the likelihood of forming friendships with Black peers having GPA distance of $|x - z|$. This term incorporates the baseline probability of friendship formation for Black students, as well as the influence of the difference in GPA on the likelihood of forming friendships within the same race. Similarly, the term $(\alpha_0^s + \alpha_{BW}^s) + (\beta_0^s + \beta_{BW}^s)|x - z|$ represents the likelihood of forming friendships with White peers.

In the same manner, the total number of friendships received for student j with a White race and a GPA of x can be calculated as follows:

$$\sum_{s \in E} N_W^s \times \int_{lb}^{ub} \left[\alpha_0^s + \beta_0^s |x - z| \right] f_W^s dz$$

$$+ \sum_{s \in E} N_B^s \times \int_{lb}^{ub} \left[(\alpha_0^s + \alpha_{WB}^s) + (\beta_0^s + \beta_{WB}^s)|x - z| \right] f_B^s dz \qquad (3)$$

The term $\alpha_0^s + \beta_0^s |x - z|$ represents the likelihood of forming friendships with White peers having a GPA distance of $|x - z|$, given that they have met each other. This term captures the baseline probability of friendship formation for White students, as well as the influence of the difference in GPA on the likelihood of forming friendships within the same race. Similarly, the term $(\alpha_0^s + \alpha_{WB}^s) + (\beta_0^s + \beta_{WB}^s)|x - z|$ represents the likelihood of forming friendships with

Black peers.

Fig. 5. Number of Friends from Data and Simulation

(a) Data

(b) Simulation

(c) Data-Simulation Comparison: Racial Friendship Gap
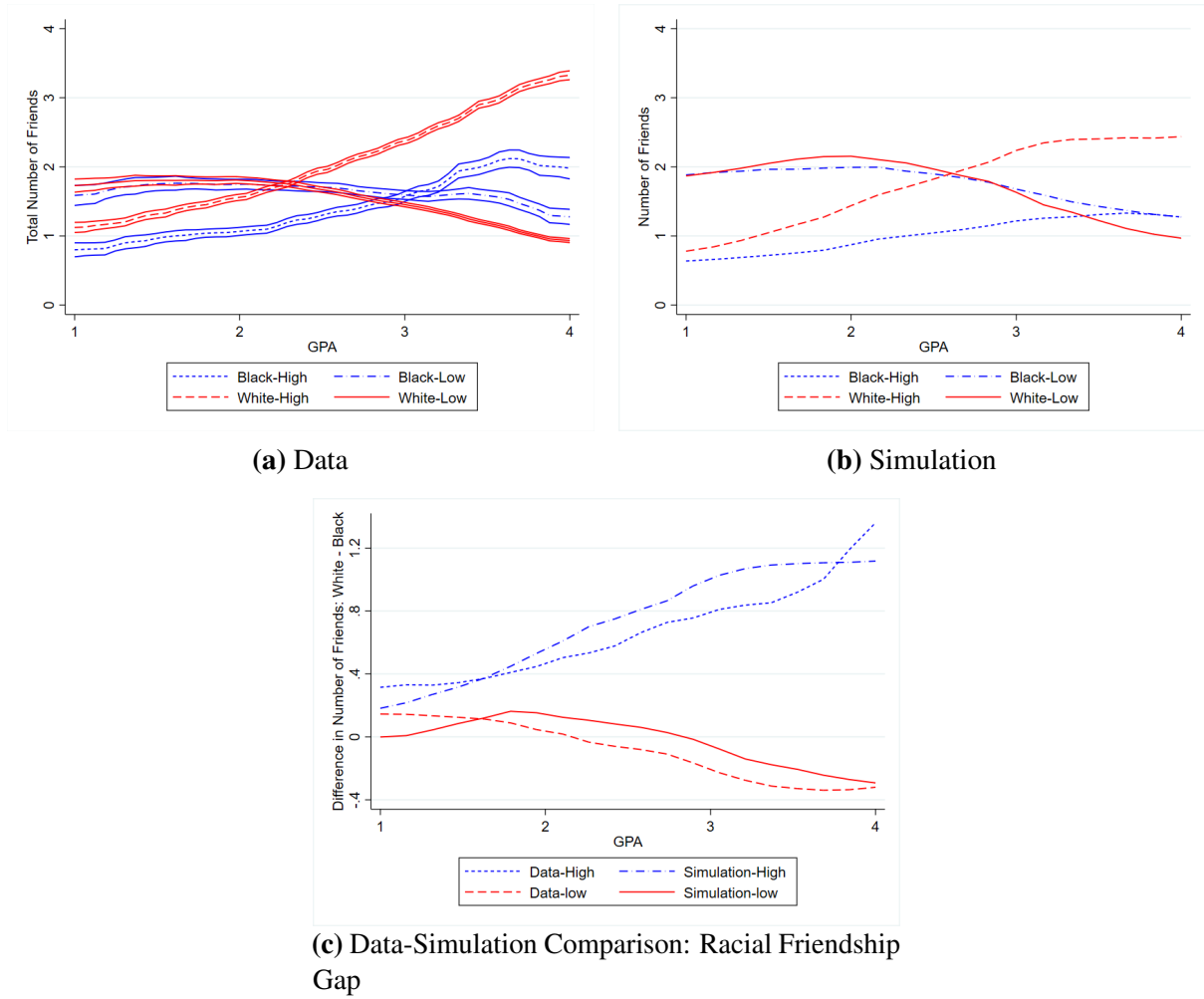
Notes. The sub-figure (a) illustrates the number of friends across GPA distribution separately by race of receiver—Black and White—and achievement of sender—high and low. We define high-achieving students as students with at least a GPA of 3.0. The short dashed blue line indicates the number of high-achieving friends of Black students. The solid red line indicates the number of low-achieving friends of White students. We use Black and White students in the in-school survey of the National Longitudinal Study of Adolescent to Adult Health. The sub-figure (b) illustrates the simulated number of friends separately for Black and White students by the sender's achievement following Equations (2) and (3). Sub-figure (c) juxtaposes the Black and White friendship gap observed in the data presented in sub-figure (a) with the corresponding simulation results depicted in sub-figure (b), delineating the analysis by high- and low-achieving friends.

In Figure 5, we present two figures. In sub-figure (a), we present the total number of friends against the receiver's GPA by race and the sender's GPA, where the sender's GPA is divided into high (3-4) and low (1-3) types. As the GPA increases, both Black and White students are more likely to receive friendship nominations from high GPA students while the slope is steeper for White students creating a larger gap for students with high GPAs. Conversely, they are less

likely to receive nominations from low GPA students as the GPA increases, but the change in the difference between Black and White is not as significant as nominations from high GPA students.

Sub-figure (b) displays the results using the above simulation based on Equations (2) and (3). The distribution of the simulated number of friends captures both qualitatively and quantitatively the patterns of the distribution of original data. We also calculate the average number of friends by GPA ranges 1-2, 2-3, and 3-4 for both data and simulation in Appendix A.6.[8] Sub-figure (c) presents the comparison between data and simulation regarding the racial difference in the number of high- and low-achieving friends. Regardless of the GPA distribution of students and the achievement of friends, the racial gap is similar between the data and simulation, affirming the model's goodness of fit. As detailed in Appendix A.6, the difference in the number of friends between our simulation and the data is consistently less than 0.2 across all GPA ranges.

In the following subsections, using the simulated number of friends we identify the factors contributing to the lower number of friends among high-achieving Black students compared to high-achieving White students by decomposing this into two distinct factors: the population size and the GPA distribution in school.

4.1   Decomposing the Friends Gap: Level and Composition Effects

We investigate the influence of changes in racial composition and GPA distribution on the racial gaps in the number of friends focusing on high-achieving students. To address this, we compare the simulated number of friends before and after the distributional shifts among Black and white students. This analysis involves two steps. First, we equalize the share of Black and White students. Second, in addition to equalization, we substitute the GPA distribution of White students for the GPA distribution of Black students. By examining these steps, we assess the impact of changes in the racial composition of the school and the GPA distribution of Black and White students on their expected friendship outcomes.

In Figure 6, we compare the expected number of high- and low-achieving friends before

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[8] An observed dissimilarity between the data and simulation is that high-achieving students tend to have fewer friends in the simulation for both Black and White students. This discrepancy might indicate an unaccounted premium for high-achievers, which our simple model does not consider. However, given our focus on racial comparisons, the omission of this factor, which affects both racial groups similarly, is unlikely to pose a significant issue in our racial comparison.

Fig. 6. Difference in the Number of Expected Friends by GPA: White - Black
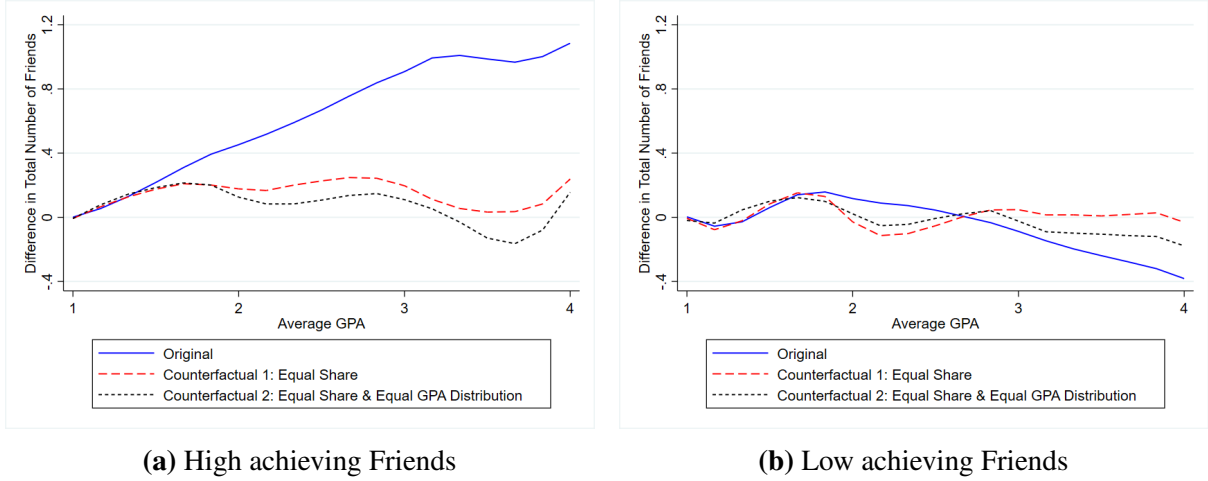
(a) High achieving Friends   **(b)** Low achieving Friends

Notes. The figure illustrates the difference in the number of expected friends between Black and White students, with a standardization of 0 at the lowest GPA level. The expected numbers are computed using equations (2) and (3). Sub-figure (a) and (b) present the difference in the number of high-achieving and low-achieving friends separately. In the figure, the solid blue line depicts the original difference in the expected number of friends. The dashed red line represents the difference assuming an equal proportion of Black and White students. The short-dashed black line represents the difference assuming both an equal share of Black and White students and an identical GPA distribution for Black and White students.

and after distributional changes.[9] The solid blue line represents the difference in the simulated number of friends between White and Black students based on Figure 5, which is normalized to have zero at the lowest GPA.[10] It is important to note that the friendship gap is mainly driven by high-achieving peers. This is particularly significant as associations between high-achieving friends and enhanced returns in the labor market have been suggested (Lleras-Muney et al. 2020). High-achieving Black students have fewer high-achieving friends compared to White counterparts, while they have more low-achieving friends. The red line depicts the difference in the expected number of friends after Black and White student shares are equalized, and the black short dashed line represents the gap after substituting the White GPA distribution for the Black GPA distribution, as well as equal shares.

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[9] We present the overall gap including both high- and low-achieving friends in Appendix A.6.

[10] Without the normalization, the expected number of friends for Black students at the lowest GPA in counterfactual 2 is larger than White students by 0.63 for high-achieving friends and 0.48 for low-achieving friends. There are reasons for this normalization. First, there are technical challenges in anticipating overall level changes when shifting compositions. This is because the overall level of racial homophily (represented as the *BB* coefficient in equation 1) is dependent on the proportion of each race due to congestion, as we observe in Table 3, and it is difficult to precisely determine the exact overall homophily level when the proportions are equal. Second, there is almost no gap in the low GPA range in both data and simulation, and the gap widens as the GPA increases. This pattern appears even though there is a discrepancy in proportion and GPA distribution. Thus, we believe it is not an extreme assumption of the same number of friends for students with the lowest GPA in our counterfactual. See Appendix A.6 for further discussion with a figure without the normalization.

Equalizing shares of Black and White students in sub-figure (a) narrows the gap in the number of friendship nominations from high performers. Specifically, the gap decreases from 1.05 to 0.16 for students with a GPA of 3-4.[11] The reduced amount, 0.89, represents the level effect. We then substitute the White GPA distribution for the GPA distribution of Black students. After substituting the White GPA distribution, the gap decreases from 0.16 to 0.07. The reduced amount, 0.09, reflects the composition effect. In total, the gap is reduced from 1.05 to 0.07 (a reduction of 93%).

In sub-figure (b) of Figure 6, we compare the difference in the expected number of friendships received from low achievers before and after distributional changes. Compared to nominations from high-achieving peers, the changes are smaller. After equalizing the shares, the gap increases from -0.26 to -0.01 for Black students with a GPA of 3-4. The increased amount, 0.25, reflects the level effect. We then compare the difference in the expected number of friendships received from low achievers before and after substituting the White GPA distribution for the Black GPA distribution. For a Black student with a GPA of 3-4, the gap decreases from -0.01 to -0.15. The reduced amount, 0.14, reflects the composition effect. In total, the gap is reduced from -0.26 to -0.15 (a reduction of 42%).

This analysis provides insights into the potential impact of altering the compositions of Black and White students on the expected number of friends particularly for high-achieving Black students compared to White counterparts. We find that high-achieving Black students have fewer friends than White counterparts because of the fewer high-achieving friends pool. Through our counterfactual analysis, We further find that most of the gap can be attributed to compositional changes, particularly level effects. In other words, the fewer friends among Black students, particularly high-achievers, are not a result of their personal characteristics or cultures, but rather the circumstances of being a minority in school.

4.2   From the Friends Gap to the Earnings Gap

In the preceding section, we established that the fewer number of friends among Black students primarily stems from structural factors, notably their status as minorities within educa-

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[11] In Appendix Table A.8, we present the numerical values of expected changes in the number of friends before and after composition changes by GPA.

tional institutions. In this section, we delve into the labor market consequences of this reduced social connectivity, particularly in relation to the racial earnings gap.

We conduct a back-of-the-envelope calculation using our estimated reduction in the friendship gap in counterfactual scenarios and the causal estimates of the return to the number of friends. According to our counterfactual analysis, the expected friendship gap among high-achieving Black students decreases from 1.05 to 0.07 for high-achieving friends and increases from -0.26 to -0.15 for low-achieving friends. Thus, the total expected decreased gap in the number of friends for high-achieving Black students is 0.87.

Following Lleras-Muney et al. (2020), we conduct an instrumental variable (IV) analysis to estimate the causal effects of the number of friends, using the average absolute difference in age between a student and their peers in the same school and grade as their instrumental variable. Thus, we assume age difference is correlated with the probability of becoming friends (McPherson, Smith-Lovin, and Cook 2001) and uncorrelated with the unobservable variations of earnings. [12] Connecting students to their earnings and other personal traits, we regress the log yearly earnings of individual i in school j in year t on the number of friends:

$$ln(earnings)_i = \gamma_0 + \gamma_b Black_i + \gamma_f NumFriend_i + \iota X_{ijg} + \delta_j + \eta_g + e_i \qquad (4)$$

where *Black* is an indicator denoting Black students, and *NumFriend* is the number of friends. We include school fixed effects, δ_j and grade fixed effects, η_g. We also include individual- and school-level controls, X_{it}, including age, sex, race, education, social skill measure, cognitive skill measure, and those school-grade averages.[13]

Table 4 presents OLS and 2SLS results, with first-stage results provided in Appendix A.7. With basic controls, Black students earn 22% less than their White counterparts, with average earnings at $36,400, and respondents primarily aged between 19 to 25 years old. In columns 2 and 3, we present OLS estimates for the number of friends for reference. Since our focus is the racial gap, we estimate returns separately for Black and White students. Column 3 further distinguishes between high- and low-achieving friends. We find no evidence of different returns

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[12] Using the same data and defining a friend in the same manner, Lleras-Muney et al. (2020) find that having one additional friend increases yearly earnings by 12.42%. See their Table 3.

[13] See Appendix A.7 for details on variable description.

Table 4: Effects of the Number of Friends on Earnings

Outcomes are Log Yearly Earnings	OLS			2SLS	
	(1)	(2)	(3)	(4)	(5)
Black	-0.224***	-0.203***	-0.205***	-0.314	-0.164
	(0.036)	(0.049)	(0.049)	(0.220)	(0.201)
Friends		0.024***		0.104*	0.124*
		(0.004)		(0.062)	(0.075)
Friends× Black		-0.004		0.048	-0.000
		(0.012)		(0.071)	(0.063)
High Performing Friends			0.029***		
			(0.004)		
Low Performing Friends			0.012**		
			(0.005)		
High Performing Friends× Black			-0.000		
			(0.013)		
Low Performing Friends× Black			-0.003		
			(0.013)		
Controls	X	X	X	X	X
IV				Overall	Race specific
Observations	7032	7032	7032	7032	7032

Notes. The table presents estimation results from equation (4). Columns 1-3 present OLS estimates and column 4-5 present 2SLS estimates where friends are endogenous. See A.7 for first-stage results. In the table, "Controls" stands for the inclusion of control variables, including age, sex, race, social skill measure, cognitive skill measure, and school and grade fixed effects. IV-Overall indicates average age distance to all students in school-grade. IV-Race specific indicates average age distance to Black and White students in school-grade separately. We use Black and White students observed both in the in-school and in-home survey of the National Longitudinal Study of Adolescent to Adult Health. Standard errors are clustered at the school level. *** $p < .01$, ** $p < .05$, * $p < .1$

to friends between Black and White students, regardless of whether friends are high-achieving or low-achieving. Additionally, we observe suggestive evidence that the return to high-achieving students is higher than that of low-achieving students.[14]

In columns (4) and (5), IV regression estimates are presented using overall age distance and race-specific distance, respectively. Overall age distance is calculated based on all possible pairs in school-grade following Lleras-Muney et al. (2020). The race-specific distance is calculated separately for Black and White peers to account for racial homophily in friendship formation, which is our preferred model. In both cases, we find a larger return to the number of friends (10.4-15.2 percent). Once again, we do not find a different return between Black and White students.[15]

In our counterfactual scenario, we anticipate a 0.87 decrease in the gap in the number of friends for high-achieving Black students, resulting in a 10.79% (12.4 * 0.87) increase in earnings. Consequently, the wage gap diminishes from 22.4% to 14.0%, representing a reduction of the gap by 8.4 percentage points (38% of the gap). The reduction of the gap might be underestimated if the causal estimate of the return to high-achieving friends exceeds that of low-achieving friends, as suggested by the OLS estimates in column (3).

5   Conclusion

The paper sheds light on a lesser-discussed disadvantage faced by students in minority groups in school. We observe that Black students tend to have fewer friends, particularly high-achieving ones, due to a limited pool of similar peers. This finding challenges previous interpretations attributing the gap to ostracization toward high-achieving minorities. Based upon the estimation results from dyadic regression examining the interaction between race and achievement, we conduct a counterfactual analysis assuming an equal proportion and the same GPA distribution of Black and White students. Under this scenario, the majority of the gap in friendships for high

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[14] The instruments lack sufficient power to produce precise estimates for different types of friendships.

[15] In different models, Lleras-Muney et al. (2020) assume the returns to education to be specific numbers, 5-15%, with consideration given to potential interactions between the number of friends and years of education. However, they find very similar results whether assuming returns to education or not. Since our estimate is almost identical to theirs despite different sample selections (excluding students other than Black and White) and different instruments (race specific age distance), we do not take additional robustness analyses taken in Lleras-Muney et al. (2020).

achievers disappears.

Furthermore, we establish a connection from the gap in friendships to the earnings gap. Our findings indicate that the disparity in the number of friends could explain an 8.4 percentage point difference in yearly earnings between Black and White individuals. Additionally, we present suggestive evidence that high-achieving friends yield greater returns compared to their low-achieving counterparts. Our paper implies that minority groups face significant disadvantages before entering the labor market even in the absence of any types of discrimination.

One significant implication of this study, albeit not discussed explicitly, is about school racial segregation, particularly regarding desegregation programs (Akbar et al. 2022; Ananat 2011; Angrist and Lang 2004; Cutler and Glaeser 1997; Mele 2020). Our work suggests that transporting minorities to White-majority schools may not necessarily reduce segregation within schools due to racial and achievement homophily. Particularly high-achieving Black students may find themselves lacking the presence of other high-achieving Black peers as a result of transportation, which is a scarce resource not easily compensated by having more high-achieving White students due to racial homophily.

While we underscore the adversities faced by minority groups in schools and emphasize that the gap may persist into the labor market, our study does not provide solutions for addressing the challenges faced by minority students nor does it advocate for racial or achievement segregation. These areas are left for future research to explore.

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ONLINE APPENDIX

Friendship Formation by Race and Achievement: Implications on Racial Gaps in Friends and Earnings

Weonhyeok Chung and Jeonghyeok Kim

Part

Appendix

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A Additional Results

A.1 Summary Statistics

Table A.1: Summary, Individual Level

	White	Black	All
GPA	2.9	2.6	2.8
Female (%)	51	55	52
Age	15	15	15
Number of Friends	3.79	3.04	3.64
High Performing (GPA$\geq$3)	2.38	1.40	2.17
Low Performing (GPA$<$3)	1.42	1.64	1.47
Share (%)	78.9	21.1	100
Observations	43,086	11,527	54,613

Notes. The total number of observations in friendship sample is 54,613 who reported GPA and individual characteristics (age, gender, and race) from the in-school survey of the National Longitudinal Study of Adolescent to Adult Health.

A.2 Calculating Probability of Forming Friends

The distribution of race and academic achievement (GPA) within schools notably impacts the extent of friendships among students. The following illustration outlines the methodology employed to generate Figure 3.

Consider a school with a total of 15 students. Within this group, there are two high-achieving Black students, three low-achieving Black students, five high-achieving White students, and five low-achieving White students.

Table A.2: Example with Pairs of 15 Students

i and j		1 B_H	2 B_H	3 B_L	4 B_L	5 B_L	6 W_H	7 W_H	8 W_H	9 W_H	10 W_H	11 W_L	12 W_L	13 W_L	14 W_L	15 W_L
1	B_H	-	1	1	1	0	0	0	0	0	1	0	0	0	0	1
2	B_H	1	-	0	1	1	0	1	0	0	0	0	0	0	0	0
3	B_L	1	0	-	1	1	0	0	0	0	1	0	0	0	0	0
4	B_L	0	0	1	-	0	0	0	0	0	0	0	0	0	1	0
5	B_L	1	1	1	1	-	0	0	0	0	1	1	0	1	0	0
6	W_H	0	0	0	0	0	-	1	1	1	0	1	0	0	0	1
7	W_H	0	0	0	0	0	1	-	1	0	1	0	0	0	0	0
8	W_H	0	0	0	0	0	1	1	-	0	0	1	0	0	0	1
9	W_H	0	0	0	0	0	1	0	0	-	1	0	0	0	0	0
10	W_H	1	1	1	0	1	0	1	1	0	-	1	0	0	0	1
11	W_L	0	0	0	0	1	1	0	1	1	1	-	1	0	1	0
12	W_L	0	0	0	0	0	0	0	0	0	0	0	-	1	0	0
13	W_L	0	0	0	0	0	0	0	0	0	0	1	0	-	1	0
14	W_L	0	0	0	1	0	0	0	0	0	0	0	0	1	-	1
15	W_L	1	0	0	0	0	1	0	1	0	1	1	1	0	1	-

Notes. This is a simple example with Black and White students with either high ability or low ability. Each row indicates a student who lists another student and each column indicates the student who are listed.

In Table A.2, we present the friendship connections among the 15 students. Each cell indicates whether student i in the row directs student j in the column as a friend. The labels in the table represent the race and achievement of the students, denoted as R_a, where R represents the race and a represents the achievement of the student. For instance, B_H in the first row (student $i = 1$) represents a high-achieving Black student. In the table, we can observe that student 2, who possesses a high-achievement, directs student 7, who possesses a high-achievement.

In Table A.3, we calculate the probabilities of forming friendships based on the data in Table A.2. For instance, consider the case of a high-achieving White student as the friendship sender

Table A.3: Probability of Forming Friendships (Example)

	B_H	B_L	W_H	W_L
B_H	100%	66.7%	20%	10%
B_L	50%	83.3%	13.3%	20%
W_H	20%	13.3%	60%	24%
W_L	10%	13.3%	28%	50%

Notes. We calculate probabilities of forming friendship for each possible race and achievement from Table A.2.

and a low-achieving Black student as the friendship receiver. In this scenario, there are 15 potential pairs (5 high-achieving White students and 3 low-achieving Black students) that can form a friendship. However, only 2 actual friendships are formed out of these potential pairs. Therefore, the probability of a high-achieving White student directing a low-achieving Black student as a friend is $\frac{2}{15} = 13.3\%$.

Fig. A.1. Probability of Forming Friendships by GPA Difference and Race (Example)
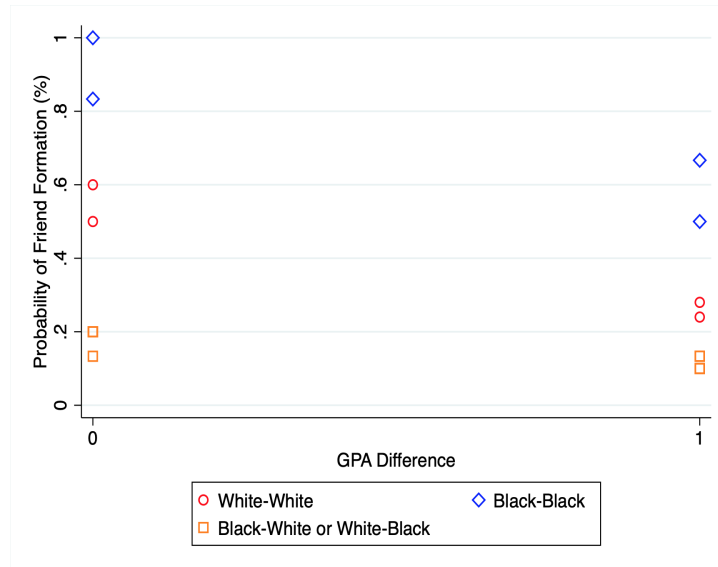
Notes. The figure illustrates average probability of friendship formation by GPA difference and race pairs based on the Table A.2. In this figure, GPA difference is 0 when two students are both high type or low type. GPA difference is 1 when two students are different achievement type (high-low or low-high types).

Using Table A.2, we plot the relationship between the GPA difference and the probability of friendship formation for each possible pair in Figure A.1. For instance, there are two cases where two Black students have identical GPAs: a high-achieving Black student directing another high-achieving Black student as a friend, and a low-achieving Black student directing another low-achieving Black student as a friend. In the figure, the likelihood of a high-achieving Black

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student directing another high-achieving Black student as a friend is 100%, while the likelihood of a low-achieving Black student directing another low-achieving Black student as a friend is 83.3%.

Compared to these equally-achieving friend pairs, the likelihood of forming a friendship decreases when students have different GPAs. The likelihood of forming a friendship between Black students with different achievement is lower than that of the equally-achieving cases. Additionally, the likelihood of forming a friendship for same-race friendships is higher than that of different-race friendships for a given GPA difference.

A.3 Mother's Years of Schooling or SES

In this subsection, we analyze the distribution of socioeconomic status (SES) groups and investigate friendship formation based on race and SES groups. We define socioeconomic status using two indicators of family background: the mother's educational attainment and whether the student lives with both parents. The high SES group includes students whose mothers have attained some college education or higher and who live with both parents. The remaining students are classified into the low SES group. Our definition of the high SES group aligns with the most advantaged group in Lundberg (2013).[A.1]

By utilizing SES groups based on family backgrounds, we also address concerns about the reverse causality between GPA and friendship formations. Instead of achievement affecting friendship formation, friendship formation may affect academic achievements. However, the measurement of the SES group is not affected by this issue as the SES group is a predetermined characteristic of students.

Fig. A.2. SES Distribution by Race

| (a) Original Share | (b) Black-White Equal Share |
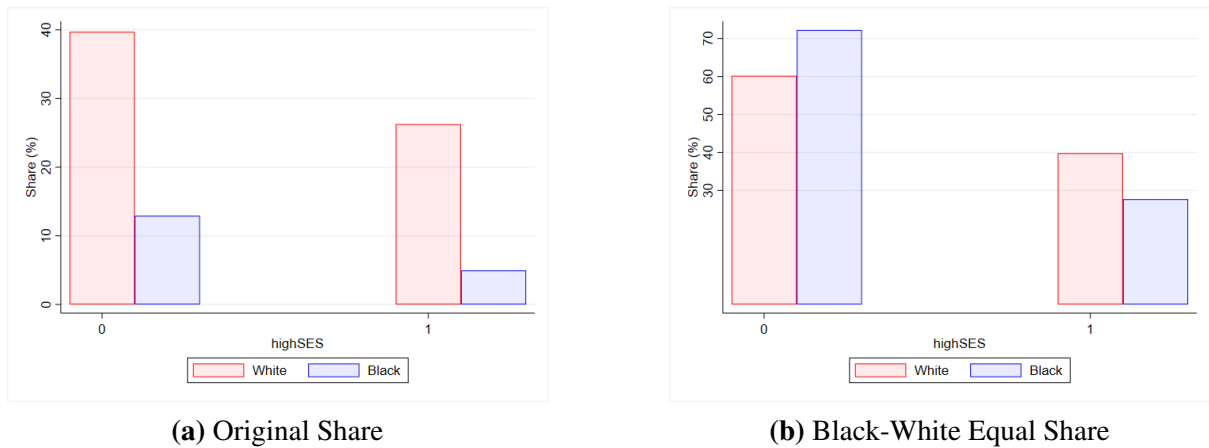
Notes. The figures illustrate the distribution of SES for Black and White students. The sub-figure (a) illustrates the distribution of SES with original Black and White shares. The sub-figure (b) illustrates the distribution of SES after equalizing Black and White shares. High SES includes students in high maternal education and residence with both parents.

Figure A.2 illustrates the distribution of socioeconomic status (SES) for Black and White students. In sub-figure (a), White students comprise the majority in both SES categories while

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[A.1] Although Lundberg (2013) defines the most advantaged group as students with both biological parents and high maternal education, we use both parents instead as we cannot identify whether both parents of students are biological parents from the in-school data that we use for the analysis.

Black students represent the minority. In sub-figure (b), the distribution of SES for Black and White students is displayed after equalizing the shares of Black and White students. The figure presents that 30 percent of Black students are in the high SES category, whereas 40 percent of White students fall into the high SES category. Consequently, within their respective racial groups, Black students have a smaller pool of potential high SES friends compared to White students.

Table A.4: Friendship Formation by Race and Social Economic Status

	Dependent variable : i denoting j as a friend (%)				
	(1)	(2)	(3)	(4)	(5)
DifferentSES	-0.078***	-0.089***	-0.083***	-0.090***	-0.110***
	(0.014)	(0.013)	(0.019)	(0.013)	(0.015)
DifferentSES $\times BB$			-0.022	-0.038**	-0.005
			(0.042)	(0.017)	(0.032)
DifferentSES $\times BW$			0.074***	0.072***	0.051**
			(0.020)	(0.020)	(0.025)
DifferentSES $\times WB$			0.063***	0.073***	0.061***
			(0.021)	(0.020)	(0.023)
BB			0.211	0.267*	1.981***
			(0.129)	(0.145)	(0.220)
BW			-0.516***	-0.546***	0.000
			(0.063)	(0.053)	(0.000)
WB			-0.495***	-0.525***	0.000
			(0.063)	(0.053)	(0.000)
Constant	0.564***	0.705***	0.626***	0.839***	0.878***
	(0.047)	(0.103)	(0.064)	(0.129)	(0.043)
Observations	30,156,736	30,156,736	30,156,736	30,156,736	30,156,736
Mean	0.530	0.530	0.530	0.530	0.530
Controls		X		X	X
Individual FE					X

Notes. The table presents coefficients and standard errors from estimation of equation (1). Units of observation are directed dyads, based on the non-Hispanic Black and non-Hispanic White students who reported mothers' education, residency with both parents, and individual characteristics (age, gender, and race) from the in-school survey of the National Longitudinal Study of Adolescent to Adult Health. The dependent variable takes on the value of 1 if student i nominated student j as a friend. DifferentSES is a binary variable equal to one if both students are in a different SES group. B indicates Black student and W indicates White student. BW is an indicator that the sender is a Black student and the receiver is a White student. Mean is the average probability of forming friendships. Controls indicates controlling for demographic variables including gender and age of senders and receivers, age difference between pairs, and school fixed effects. Individual FE indicates controlling for individual fixed effects of senders and receivers. *** $p < .01$, ** $p < .05$, * $p < .1$

Table A.4 presents estimation results in Equation (1) with and without covariates, using the SES groups instead of GPA. In column (1), if the SES groups differ, the probability of friendship

formation between two students decreases by 0.078 percentage points when the overall mean is 0.53 percent. In column (2), when we control for additional characteristics, including dyad-level characteristics (age and gender pairs) and demographic variables related to the senders' or receivers' genders and ages, the coefficient becomes more pronounced. In column (2), the results indicate that when the SES group differs, the probability of friendship formation between two students in the school decreases by 0.089 percentage points.

In column (3), we find that different SES matters similarly between pairs of White students and pairs of Black students. In column (4), We find similar results to those in column (3) after controlling dyad-level and individual-level characteristics. In column (5), we control sender fixed effects and receiver fixed effects. Regardless of whether we control for individual fixed effects, we find that the difference in SES matters similarly in friendship formation for Black and White students. Moreover, the significance of the SES difference is more pronounced for within-race friendships compared to across-race friendships, regardless of the control variables.

A.4 Different Black Share of Schools

In this subsection, we provide additional information about the characteristics of schools based on the proportion of Black students. Figure A.3 displays figures, illustrating the distribution of GPA among Black and White students, both with and without equalizing the shares of each race, across different proportions of Black students. Two notable patterns emerge: i) Black students predominantly cluster in the middle of the GPA distribution, while White students tend to be concentrated at the top of the GPA distribution; ii) the disparity in the proportion of high-performing students between Black and White students is more pronounced in schools with a Black minority.

We also provide Table A.5 controlling for sender and receiver fixed effects, which complements Table 3 in the main text.

Lastly, Figures A.4, A.5, and A.6 depict various school characteristics across different proportions of Black students. Black-majority schools are more inclined to be public, located in suburban or rural areas, situated in the South, and characterized by a small to medium size. Conversely, White-majority schools are more likely to be private, located in the Northeast or West, and characterized by a larger size.
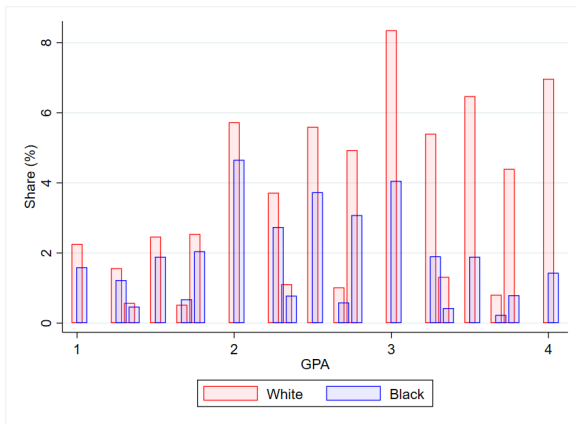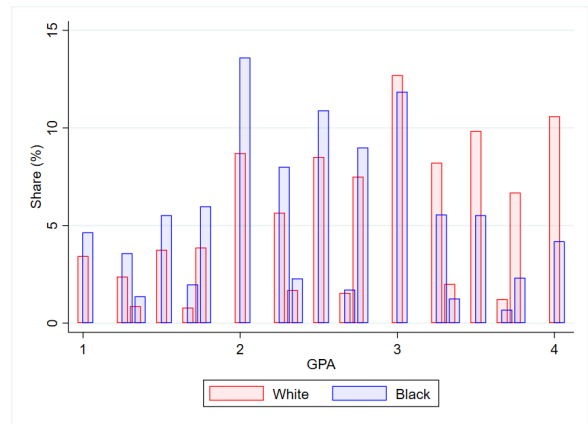
Fig. A.3. GPA Distribution by Average GPA
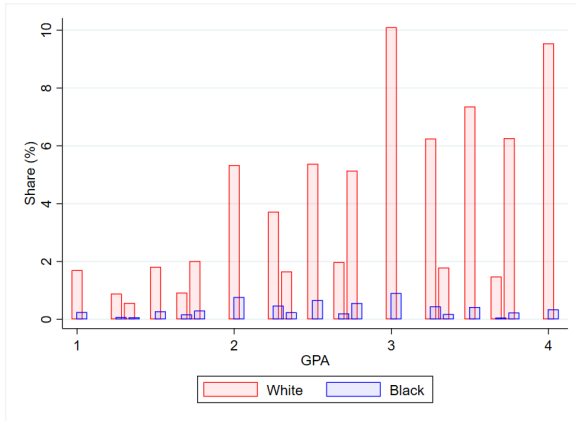
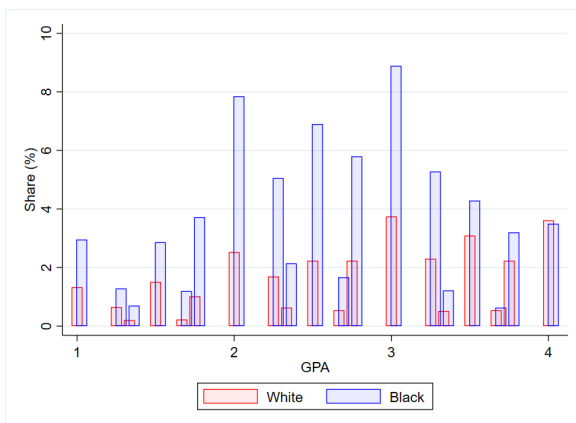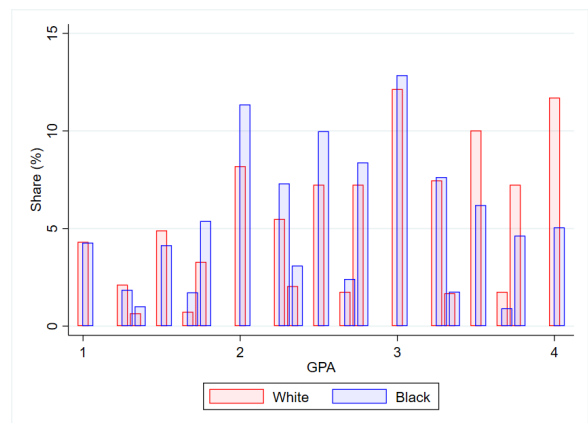(a) Original Shares (Black 0-22%)
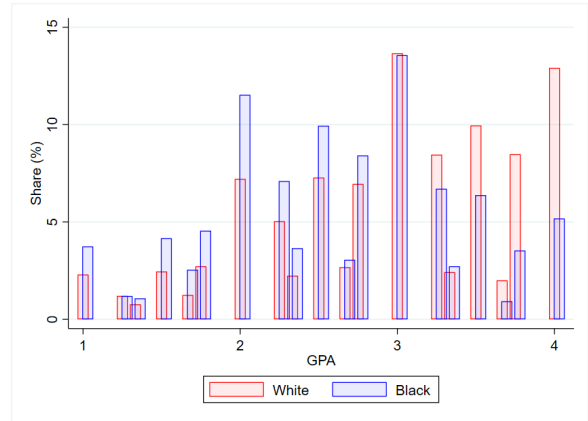
(b) Equal Shares (Black 0-22%)

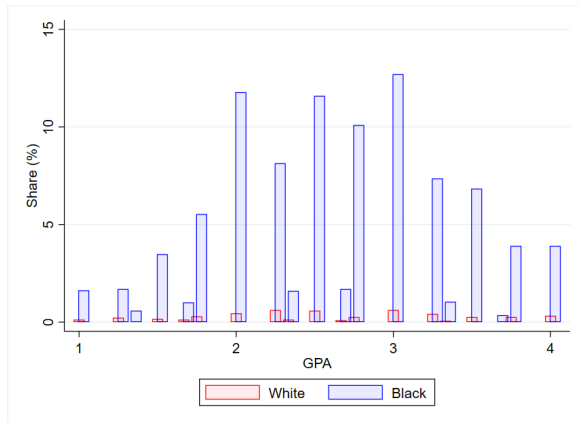(c) Original Shares (Black 23-40%)

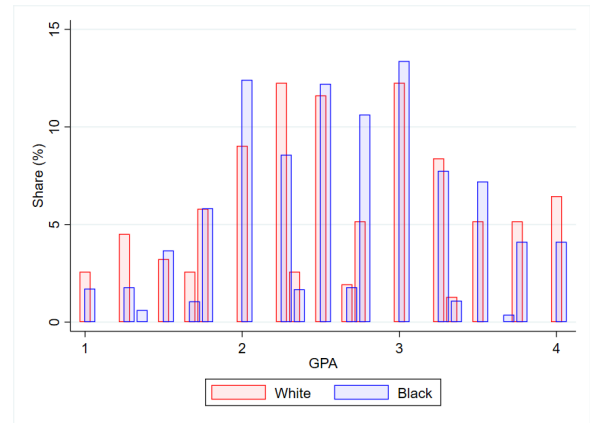(d) Equal Shares (Black 23-40%)

(e) Original Shares (Black 41-74%)

(f) Equal Shares (Black 41-74%)

(g) Original Shares (Black 75-100%)

(h) Equal Shares (Black 75-100%)

Notes. The figures illustrate the distributions of average GPA for Black and White students, separately by proportion of Black students in school. The red bar indicates the density of the average GPA of White students. The blue bar indicates the density of the average GPA of Black students. We use Black and White students in the in-school data of the National Longitudinal Study of Adolescent to Adult Health. The sub-figures (a), (c), (e), and (g), illustrates the average GPA distribution with original Black and White shares. The sub-figures (b), (d), (f), and (h), illustrates the average GPA distribution after equalizing Black and White shares.

Table A.5: Friendship Formation by Race and Achievement: Across Black Student Proportion with Individual Fixed-Effects

	(1) All	(2) 0-22%	(3) 23-40%	(4) 41-74%	(5) 75-100%
		Dependent variable :			
		Probability of i denoting j as a friend (%)			
dGPA	-0.259***	-0.248***	-0.359***	-0.269***	-1.406***
	(0.028)	(0.029)	(0.078)	(0.035)	(0.124)
$dGPA \times BB$	0.038	-0.080	0.094**	0.146***	1.136***
	(0.049)	(0.075)	(0.039)	(0.031)	(0.120)
$dGPA \times BW$	0.200***	0.165***	0.295***	0.221***	1.298***
	(0.025)	(0.025)	(0.067)	(0.039)	(0.106)
$dGPA \times WB$	0.193***	0.154***	0.281***	0.229***	1.354***
	(0.026)	(0.024)	(0.067)	(0.037)	(0.097)
Constant	0.938***	1.154***	0.870***	0.097	-4.600***
	(0.051)	(0.070)	(0.056)	(0.111)	(0.244)
Observations	36,183,256	26,910,900	4,993,870	2,743,852	1,534,634
Mean	0.513	0.509	0.539	0.400	0.681

Notes. The table presents coefficients and standard errors from estimation of equation (1), separately by the share of Black students. Units of observation are directed dyads, based on non-Hispanic Black and non-Hispanic White students who reported GPAs and individual characteristics (age, gender, and race) from the in-school survey of the National Longitudinal Study of Adolescent to Adult Health. The dependent variable takes on the value of 1 if student i nominated student j as a friend. *dGPA* indicates a difference in average GPA between the pairs of students. B indicates Black students, and W indicates White students. The schools are divided into four quantile groups as follows: the first quantile (Q1) includes schools with Black student shares ranging from 0% to 22%; the second quantile (Q2) includes schools with Black student shares between 23% and 40%; the third quantile (Q3) includes schools with Black student shares between 41% and 74%; and the fourth (Q4) quantile includes schools with Black student shares between 75% and 100%. *** $p < .01$, ** $p < .05$, * $p < .1$

Fig. A.4. School Characteristics Across Black Student Proportion: Public, Urban, Suburban, and Rural
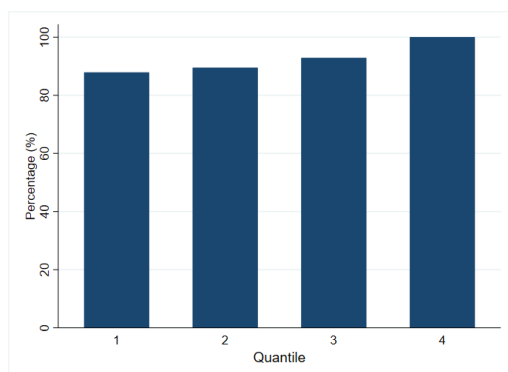
(a) Fraction of Public Schools
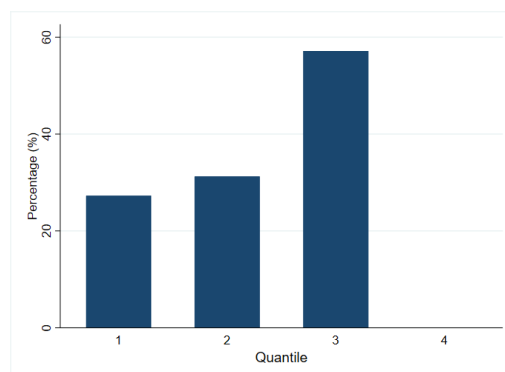
(b) Fraction of Urban Schools
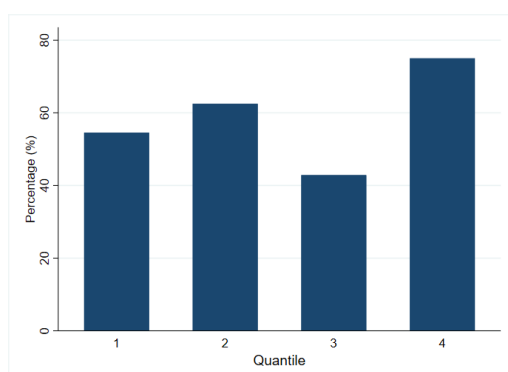
(c) Fraction of Suburban Schools
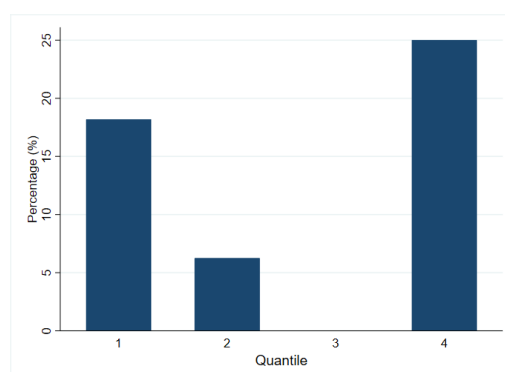
(d) Fraction of Rural Schools

Notes. We divide schools into four groups as each group has the same number of black students: the first, second, third, and fourth groups include schools with Black student shares ranging from 0% to 22%, 23% to 40%, 41% to 74%, and 75% to 100%, respectively.

Fig. A.5. School Characteristics Across Black Student Proportion: Midwest, Northeast, South, and West
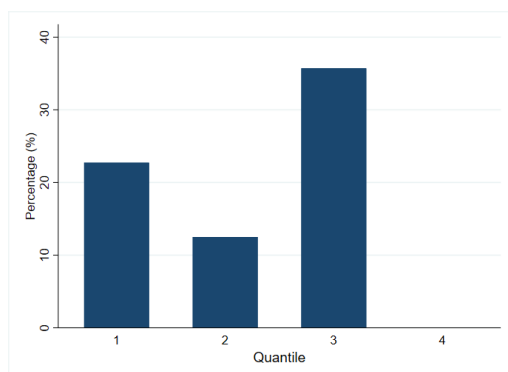
(a) Fraction of Schools in Midwest

(b) Fraction of Schools in Northeast
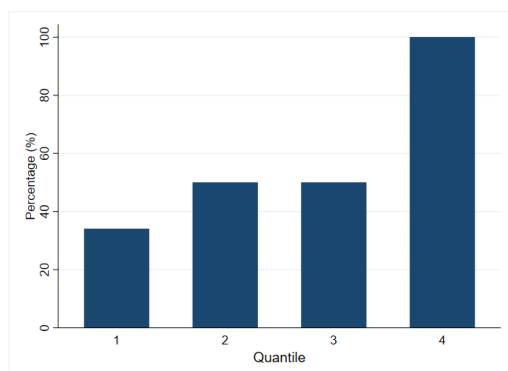
(c) Fraction of Schools in South
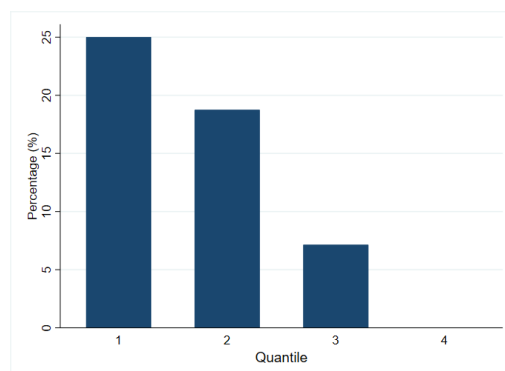
(d) Fraction of Schools in West

Notes. We divide schools into four groups as each group has the same number of black students: the first, second, third, and fourth groups include schools with Black student shares ranging from 0% to 22%, 23% to 40%, 41% to 74%, and 75% to 100%, respectively.

Fig. A.6. School Characteristics Across Black Student Proportion: Large, Medium, and Small Size Schools
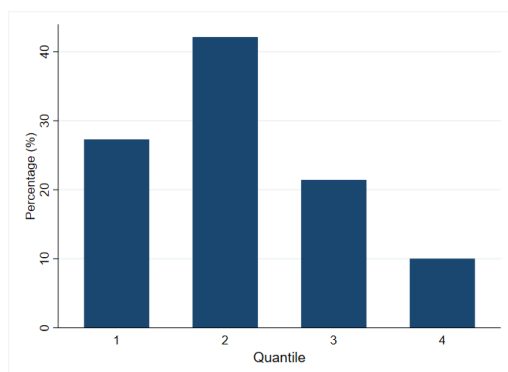
(a) Fraction of Large Size School (1,001 to 4,000 students)
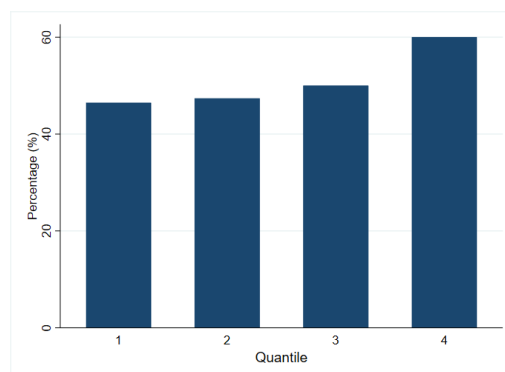
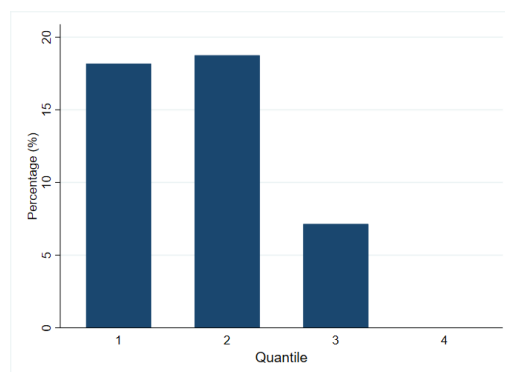**(b)** Fraction of Medium Size School (401 to 1,000 students)
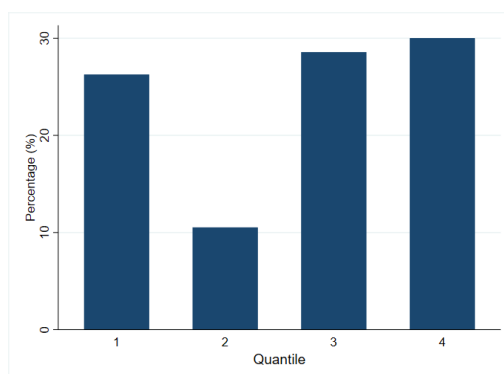
(c) Fraction of Small Size School (1 to 400 students)

Notes. We divide schools into four groups as each group has the same number of black students: the first, second, third, and fourth groups include schools with Black student shares ranging from 0% to 22%, 23% to 40%, 41% to 74%, and 75% to 100%, respectively.

A.5 Forming Friendships within School Clubs

In Table A.6, we examine whether the difference in GPA has varying implications for friendship formation when students are members of the same social club or not. The variable *Club* indicates whether the two students are both members of at least one social club. Our findings show that students who share membership in a club are more likely to form friendships compared to those who do not share club membership. Furthermore, we observe that the difference in GPA matters more on friendship formation for student pairs who are part of the same club (*Club* × *dGPA*). In other words, even when students belong to the same club, the likelihood of forming friendships diminishes if there are larger differences in their GPAs. These findings address concerns that the formation of friendships is solely influenced by exposure rather than the active choice of students. In addition, we do not find a significant difference between White-White pairs and Black-Black pairs, regardless of their involvement in the social club (*Club* × *dGPA* × *BB* and *dGPA* × *BB*).

Table A.6: Friendship Formation by Race and Achievement: Within School Clubs

	Dependent variable : i denoting j as a friend (%)	
	(1)	(2)
$Club \times dGPA$	-0.355***	-0.353***
	(0.046)	(0.041)
$Club \times dGPA \times BB$	0.103	0.116
	(0.095)	(0.085)
$Club \times dGPA \times BW$	0.283***	0.288***
	(0.046)	(0.044)
$Club \times dGPA \times WB$	0.285***	0.290***
	(0.045)	(0.042)
$Club \times BB$	-0.123	-0.106
	(0.230)	(0.199)
$Club \times BW$	-0.962***	-0.936***
	(0.109)	(0.107)
$Club \times WB$	-0.923***	-0.896***
	(0.107)	(0.104)
$Club$	1.242***	1.096***
	(0.110)	(0.098)
$dGPA$	-0.130***	-0.127***
	(0.016)	(0.015)
$dGPA \times BB$	0.012	0.002
	(0.030)	(0.032)
$dGPA \times BW$	0.113***	0.100***
	(0.016)	(0.016)
$dGPA \times WB$	0.108***	0.100***
	(0.016)	(0.016)
BB	0.207	0.228
	(0.125)	(0.140)
BW	-0.434***	-0.489***
	(0.057)	(0.052)
WB	-0.413***	-0.470***
	(0.057)	(0.052)
Constant	0.526***	0.592***
	(0.058)	(0.125)
Observations	36,183,256	36,183,256
Mean	0.5	0.5
Controls		X

Notes. The table presents coefficients and standard errors from estimation of equation (1).Units of observation are directed dyads, based on the non-Hispanic Black and non-Hispanic White students who reported GPAs and individual characteristics (age, gender, and race) from the in-school survey of the National Longitudinal Study of Adolescent to Adult Health. The dependent variable takes on the value of 1 if student i nominated student j as a friend. *dGPA* indicates a difference in average GPA between the pairs of students. *Club* is a binary variable equal to one if both students were in at least one extracurricular activity. *B* indicates Black students, and *W* indicates White students. *** $p < .01$, ** $p < .05$, * $p < .1$

A.6   Additional Simulation Outcomes

We present supplementary results for simulation analysis. Table A.7 displays the number of friends categorized by students' GPA (1-2, 2-3, 3-4), students' race (Black, White), and friends' GPA (high-achieving, low-achieving). Furthermore, we illustrate the disparity in the number of friends between Black and White students, as well as the difference between data and simulation regarding the racial gap in friendship counts. Table A.8 provides numerical values for the difference in the number of friends in each counterfactual analysis, complementing Figure 6. Figure A.7 displays the total number of friends gap, including both high- and low-achieving friends.

Finally, Figure A.8 illustrates the friendship gap in the original simulation and each counterfactual scenario without normalization, where the gap is set to zero at the lowest GPA. In counterfactual 1, we equalize the proportions of Black and White students, resulting in the near elimination of the racial gap in high-achieving friends, while the gap in low-achieving friends becomes at around negative 1.0. This suggests that Black students are expected to have approximately one more low-achieving friend compared to White students. In counterfactual 2, we further equalize their GPA distributions, revealing that Black students have approximately 0.5 more high- and low-achieving friends.

However, it is important to note that the more friends of Black students compared to White in the counterfactuals may be influenced by the higher level of racial homophily due to the smaller proportion of Black students. In our regression model (equation 1), the overall level of racial homophily is determined by the probability of forming friendships among all possible pairs. Since the number of friends is constrained to a certain level (i.e., congestion), the overall level of homophily may be overestimated when the number of Black students is limited.[A.2] Therefore, even if our estimation suggests that Black students have more friends, we focus on relative levels where overall homophily cannot exert influence. If there is an overall difference between races in preferences for forming friendships, and thus Black students have a higher number of friends in our counterfactual scenarios, the reduced gap in the number of friends from

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[A.2] For example, having 10 Black friends among 20 Black peers results in a probability of 0.5. If there are 40 Black students, a student would need to have 20 Black friends to achieve the same probability. However, it is unrealistic to expect individuals to have such a large number of friends due to time and resource constraints.

our counterfactuals may be underestimated.

Table A.7: Number of friends by Type of Friends and GPA

	Black Students		White Students		Difference (White - Black)	
	(1) Low-Perform Friends	(2) High-Perform Friends	(3) Low-Perform Friends	(4) High-Perform Friends	(5) Low-Perform Friends	(6) High-Perform Friends
Data						
GPA 1-2	1.71	0.98	1.79	1.37	0.08	0.39
GPA 2-3	1.66	1.37	1.60	2.10	-0.06	0.73
GPA 3-4	1.51	1.98	1.10	3.07	-0.41	1.09
Simulation Results						
GPA 1-2	1.98	0.77	2.08	1.18	0.10	0.41
GPA 2-3	1.87	1.11	1.87	2.00	0.00	0.89
GPA 3-4	1.44	1.28	1.15	2.44	-0.29	1.16
Difference (Data - Simulation)						
GPA 1-2	-0.27	0.21	-0.29	0.19	-0.02	-0.02
GPA 2-3	-0.21	0.26	-0.27	0.10	-0.06	-0.16
GPA 3-4	0.07	0.70	-0.05	0.63	-0.12	-0.07

Notes. This table illustrates the number of friends based on the race of receivers and the achievement types of both receivers and senders. Receiver achievement is categorized into GPA ranges 1-2, 2-3, and 3-4, while sender achievement is divided into low (1-3) and high (3-4). The data panel presents the average number of friends in our dataset, while the Simulation Results panel presents the simulated number of friends.

Table A.8: The Difference in the Number of Friends (White - Black) Before and After Composition Changes.

Panel A: High-Performing Friends			
	GPA 1-2	GPA 2-3	GPA 3-4
Simulation	0.31	0.75	1.05
Counterfactual 1: Equal Share	0.17	0.21	0.16
Counterfactual 2: Equal Share & Equal GPA Dist.	0.16	0.11	0.07
Panel B: Low-Performing Friends			
	GPA 1-2	GPA 2-3	GPA 3-4
Simulation	0.08	0.01	-0.26
Counterfactual 1: Equal Share	0.01	-0.01	-0.01
Counterfactual 2: Equal Share & Equal GPA Dist.	0.03	-0.01	-0.15

Notes. The table illustrates the difference in the number of expected friends between Black and White students, with standardization of 0 at the lowest GPA level. The expected numbers are computed using equations (2) and (3). Panel (a) and (b) present the difference in the number of high-performing and low-performing friends separately. In the table, the simulation presents the original difference in the expected number of friends. Counterfactual 1 presents the difference assuming an equal proportion of Black and White students. Counterfactual 2 presents the difference assuming both an equal share of Black and White students and an identical GPA distribution for Black and White students.

Fig. A.7. Difference in Number of Expected Friends by GPA: White - Black
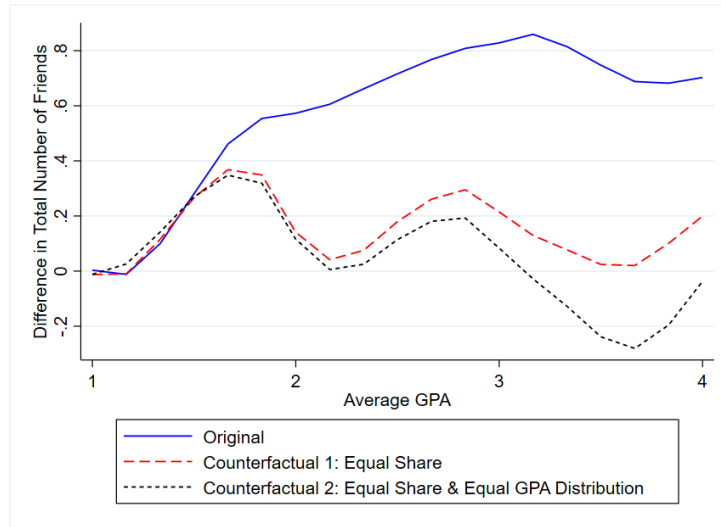
Notes. The figure illustrates the difference in the number of expected friends between Black and White students, with standardization of 0 at the lowest GPA level. The expected numbers are computed using Equations (2) and (3). In the graph, the solid blue line depicts the original difference in the expected number of friends. The dashed red line represents the difference assuming an equal proportion of Black and White students. The short-dashed black line represents the difference assuming both an equal share of Black and White students and an identical GPA distribution for Black and White students.

Fig. A.8. Difference in the Number of Expected Friends by GPA Without Normalization: White - Black
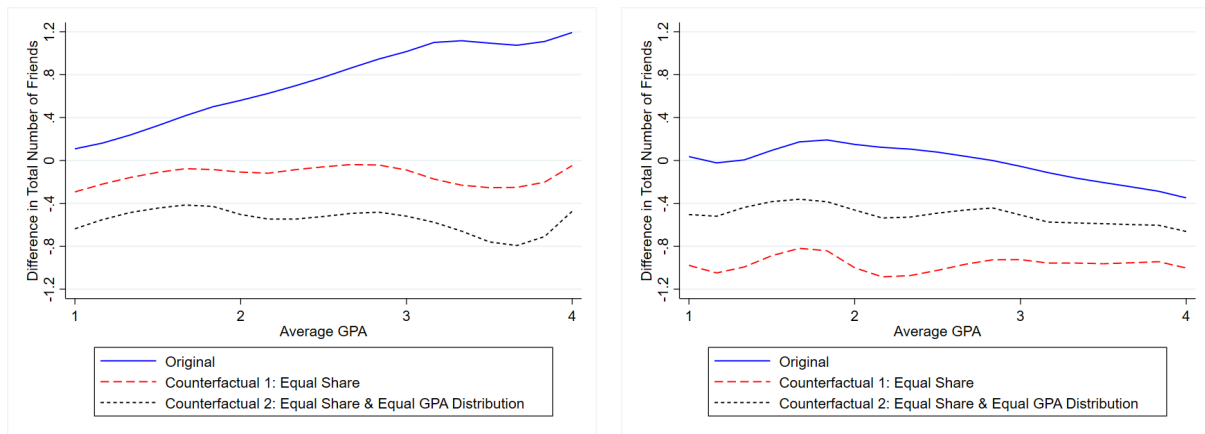
(a) High achieving Friends   **(b)** Low achieving Friends

Notes. The figure illustrates the difference in the number of expected friends between Black and White students. The expected numbers are computed using equations (2) and (3). Sub-figure (a) and (b) present the difference in the number of high-achieving and low-achieving friends separately. In the graph, the solid blue line depicts the original difference in the expected number of friends. The dashed red line represents the difference assuming an equal proportion of Black and White students. The short-dashed black line represents the difference assuming both an equal share of Black and White students and an identical GPA distribution for Black and White students.

A.7 Additional Earnings Outcomes

We further restrict our sample for labor market analysis to include individuals who report measures of cognitive skills, social skills, education level, and earnings. Consistent with Lleras-Muney et al. (2020), cognitive skills are assessed using the Add Health Picture Vocabulary Test (AHPVT) score administered in Wave 1, while social skills are gauged through self-reported extroversion levels collected in Wave 2.[A.3] Earnings are measured as total earnings from wages or salary in the previous year. We utilize earnings data from Waves 4, corresponding to ages 18-26. Respondents who responded "do not know" to the earnings question were presented with twelve earnings categories, and we approximate their earnings by using the midpoint of the selected range. On average, individuals in our sample earned approximately $36,400 in the preceding year.

Table A.9 presents the first-stage results of our IV estimation. In column 1, we use age distance to peers in the same school and grade as our instrument, which is also interacted with Black student dummy to examine potential racial differences in the return to friendships. Specifically, the distance is the average of absolute difference between all possible pairs in the group with a student. In column 2, we disaggregate the age distance into two components: distance to Black and White peers in the same school and grade. Thus, each student has two age distance variables: one with Black peers and the other with White peers. The rationale is that the age distance measure may predominantly reflect distance to White students, even if Black students are more inclined to form friendships with other Black students. In both cases, we observe a strong relationship between friendship and age distance variables.

[A.3] The survey question is "You are shy?", and the choices are "strongly agree, agree, neither agree nor disagree, disagree, strongly disagree". Individuals choosing last three categories are defined as extrovert. Due to the survey design, 26% of the individuals in the dataset lack this information. Consequently, we impute this measure and incorporate a dummy variable to indicate its absence.

Table A.9: First-Stage: Effects of Age Distance on the Number of Friendships

Outcomes are Number of Friends	(1)	(2)
Age distance	-1.257***	
	(0.171)	
Age distance× Black	-0.172	
	(0.142)	
Age distance to Black Peers		-0.026
		(0.122)
Age distance to White Peers		-1.054***
		(0.202)
Age distance to Black Peers× Black		-0.740*
		(0.358)
Age distance to White Peers× Black		0.517
		(0.339)
F-stat of Homophily Measures	36.798	18.962
P-value	0.000	0.000
R^2	0.045	0.044
Observations	7,032	7,032

Notes. In the table, "Controls" stands for the inclusion of control variables, including age, sex, race, social skill measure, cognitive skill measure, and school and grade fixed effects. Age distance is the average age distance to all students in the same school and grade. Age distance to Black (white) peers is the average age distance to all Black (White) students in the same school and grade. Black is the dummy variable taking 1 if student is Black. We use Black and White students observed both in the in-school and in-home survey of the National Longitudinal Study of Adolescent to Adult Health. Standard errors are clustered at the school level. *** $p < .01$, ** $p < .05$, * $p < .1$

B   Robustness Checks

B.1   Mutual Friendship Measures

Table B.1: Friendship Formation by Race and Achievement: Mutual Friendship (Both)

	Dependent variable : i denoting j as a friend (%)				
	(1)	(2)	(3)	(4)	(5)
$dGPA$	-0.095***	-0.078***	-0.112***	-0.093***	-0.131***
	(0.010)	(0.008)	(0.013)	(0.011)	(0.015)
$dGPA \times BB$			0.036*	0.022	0.034
			(0.021)	(0.022)	(0.025)
$dGPA \times BW$			0.100***	0.086***	0.104***
			(0.013)	(0.012)	(0.013)
$dGPA \times WB$			0.100***	0.086***	0.104***
			(0.013)	(0.012)	(0.013)
BB			0.002	0.026	0.928***
			(0.065)	(0.069)	(0.108)
BW			-0.295***	-0.296***	0.000
			(0.035)	(0.029)	(0.000)
WB			-0.295***	-0.296***	0.000
			(0.035)	(0.029)	(0.000)
Constant	0.289***	0.088	0.335***	0.178***	0.373***
	(0.026)	(0.054)	(0.036)	(0.064)	(0.021)
Observations	36,183,256	36,183,256	36,183,256	36,183,256	36,183,256
Mean	0.208	0.208	0.208	0.208	0.208
Controls		X		X	X
Individual FE					X

Notes. Units of observation are undirected dyads, based on the 54,850 non-Hispanic Black and non-Hispanic White students who reported GPAs and individual characteristics (age, gender, and race) from the in-school survey of the National Longitudinal Study of Adolescent to Adult Health. The dependent variable takes on the value of 1 if student i and student j both listed each other as a friend. *dGPA* indicates a difference in average GPA between the pairs of students. *B* indicates Black students, and *W* indicates White students. *** $p < .01$, ** $p < .05$, * $p < .1$

In our dyadic analysis, we measure friendships based on directed numbers, where one student (i) directs another (j) as their friend. However, in Table B.1, we examine the sensitivity of our friendship measure by using a stricter definition of friendship: mutual friendship, where both students mutually direct each other as friends. While this stricter definition results in a smaller probability of forming friendships compared to the baseline measure, our findings are qualitatively unchanged. The difference in GPA matters again similarly between pairs of Black students and pairs of White students (*dGPA* × *BB*). Additionally, we find that the difference

in GPA matters less on across-race friendship formations compared to within-race friendships ($dGPA \times BW$ and $dGPA \times WB$).

Table B.2: Friendship Formation by Race and Achievement: Mutual Friendship (Either)

	Dependent variable : i denoting j as a friend (%)				
	(1)	(2)	(3)	(4)	(5)
$dGPA$	-0.282***	-0.251***	-0.319***	-0.284***	-0.388***
	(0.028)	(0.023)	(0.037)	(0.032)	(0.041)
$dGPA \times BB$			0.058	0.012	0.041
			(0.067)	(0.069)	(0.074)
$dGPA \times BW$			0.270***	0.229***	0.289***
			(0.036)	(0.033)	(0.038)
$dGPA \times WB$			0.270***	0.229***	0.289***
			(0.036)	(0.033)	(0.038)
BB			0.334	0.475*	3.574***
			(0.267)	(0.275)	(0.398)
BW			-0.926***	-0.935***	0.000
			(0.122)	(0.093)	(0.000)
WB			-0.926***	-0.935***	0.000
			(0.122)	(0.093)	(0.000)
Constant	1.060***	1.299***	1.168***	1.546***	1.503***
	(0.094)	(0.147)	(0.125)	(0.200)	(0.080)
Observations	36,183,256	36,183,256	36,183,256	36,183,256	36,183,256
Mean	0.817	0.817	0.817	0.817	0.817
Controls		X		X	X
Individual FE					X

Notes. Units of observation are undirected dyads, based on the 54,850 non-Hispanic Black and non-Hispanic White students who reported GPAs and individual characteristics (age, gender, and race) from the in-school survey of the National Longitudinal Study of Adolescent to Adult Health. The dependent variable takes on the value of 1 if at least one of students i and j listed another student as a friend. *dGPA* indicates a difference in average GPA between the pairs of students. *B* indicates Black students, and *W* indicates White students. *** $p < .01$, ** $p < .05$, * $p < .1$

Moreover, we alternatively define the mutual friendship measure, where if at least one student directs the other as a friend, both the $i - j$ and $j - i$ pairs are considered as forming friendships. The results are presented in Table B.2. This looser definition of friendship results in a higher probability of forming friendships compared to our baseline measure. However, our findings are qualitatively unchanged. The difference in GPA matters once again similarly between pairs of Black students and pairs of White students. We find that the difference in GPA matters less on across-race friendship formations compared to within-race friendships.

B.2 Asymmetric GPA Measures

In Table B.3, we further examine whether the GPA gap matters differently when students direct another with a higher or lower GPA. The variable *ReceivingHighGPA* indicates that the sender student (i) has a lower GPA than the receiver student (j). We find that the relationship between the GPA gap and friendship formation is weaker when the receiver has a higher GPA (*ReceiverHighGPA* $\times$ *dGPA*). This suggests that the difference in GPA matters differently when a student directs another student with a higher or lower GPA. However, we do not find a significant difference between White-White pairs and Black-Black pairs, regardless of the direction from lower GPA to higher GPA or higher GPA to lower GPA (*ReceiverHighGPA* $\times$ *dGPA* $\times$ *BB* and *dGPA* $\times$ *BB*).

Table B.3: Friendship Formation by Race and Achievement: Asymmetric GPA

	Dependent variable : i denoting j as a friend (%)	
	(1)	(2)
$ReceiverHighGPA \times dGPA$	0.032***	0.132***
	(0.006)	(0.016)
$ReceiverHighGPA \times dGPA \times BB$	-0.018	-0.015
	(0.021)	(0.020)
$ReceiverHighGPA \times dGPA \times BW$	-0.040***	-0.046***
	(0.009)	(0.014)
$ReceiverHighGPA \times dGPA \times WB$	0.003	0.006
	(0.012)	(0.014)
$ReceiverHighGPA \times BB$	0.033	0.029
	(0.025)	(0.023)
$ReceiverHighGPA \times BW$	0.021**	0.017*
	(0.008)	(0.010)
$ReceiverHighGPA \times WB$	0.024**	0.031***
	(0.011)	(0.011)
$ReceiverHighGPA$	-0.030***	-0.019***
	(0.007)	(0.005)
$dGPA$	-0.229***	-0.253***
	(0.027)	(0.028)
$dGPA \times BB$	0.054	0.022
	(0.044)	(0.045)
$dGPA \times BW$	0.209***	0.187***
	(0.026)	(0.024)
$dGPA \times WB$	0.186***	0.158***
	(0.026)	(0.025)
BB	0.153	0.240
	(0.164)	(0.169)
BW	-0.631***	-0.636***
	(0.079)	(0.061)
WB	-0.608***	-0.616***
	(0.079)	(0.061)
Constant	0.762***	0.868***
	(0.081)	(0.129)
Observations	36,519,842	36,183,256
Mean	0.5	0.5
Controls		X

Notes. Units of observation are directed dyads, based on non-Hispanic Black and non-Hispanic White students who reported GPAs and individual characteristics (age, gender, and race) from the in-school survey of the National Longitudinal Study of Adolescent to Adult Health. The dependent variable takes on the value of 1 if student i nominated student j as a friend. *dGPA* indicates a difference in average GPA between the pairs of students. *B* indicates Black students, and *W* indicates White students. *** $p < .01$, ** $p < .05$, * $p < .1$

B.3 Semiparametric GPA Measures

We explore whether low and high GPA students exhibit different patterns when they form friendships with low and high GPA peers. We divide students into two GPA groups: low (average GPA 1-3) and high (average GPA 3-4). Then, we examine the difference across races when a student i with a low (or high) GPA forms a friendship with a student j with a low (or high) GPA. The results are presented in Table B.4. First, we observe a higher probability of forming friendships within the same GPA groups than across GPA groups. Particularly, stronger homophily exists among high GPA students. Regardless of whether a student with a low (or high) GPA forms friendships with a student with a low (or high) GPA, however, the GPA gap matters less or similarly to Black-Black pairs compared to White-White pairs. Additionally, we further explore the differences using three levels of GPA: low (average GPA 1-2.5), middle (average GPA 2.5-3.25), and high (average GPA 3.25-4), as shown in Table B.5. Once again, we find that the GPA gap matters similarly or less on friendships for Black-Black pairs compared to White-White pairs.

Table B.4: Friendship Formation by Race and Achievement: Semiparametric Low-High

	Dependent variable : i denoting j as a friend (%)	
	(1)	(2)
$GPAi : low \times GPAj : high \times BW$	0.060***	0.053**
	(0.022)	(0.021)
$GPAi : low \times GPAj : high \times WB$	0.113***	0.104***
	(0.025)	(0.021)
$GPAi : low \times GPAj : high \times BB$	0.076	0.069**
	(0.047)	(0.031)
$GPAi : high \times GPAj : low \times BW$	0.115***	0.106***
	(0.024)	(0.021)
$GPAi : high \times GPAj : low \times WB$	0.060**	0.053**
	(0.023)	(0.023)
$GPAi : high \times GPAj : low \times BB$	0.040	0.032
	(0.045)	(0.027)
$GPAi : high \times GPAj : high \times BW$	-0.214***	-0.221***
	(0.075)	(0.055)
$GPAi : high \times GPAj : high \times WB$	-0.209***	-0.216***
	(0.075)	(0.053)
$GPAi : high \times GPAj : high \times BB$	0.174	0.126
	(0.244)	(0.192)
$GPAi : low \times GPAj : high$	-0.074***	-0.066***
	(0.021)	(0.009)
$GPAi : high \times GPAj : low$	-0.087***	-0.089***
	(0.023)	(0.012)
$GPAi : high \times GPAj : high$	0.298***	0.283***
	(0.075)	(0.041)
BB	0.214*	0.237*
	(0.114)	(0.129)
BW	-0.452***	-0.499***
	(0.057)	(0.052)
WB	-0.429***	-0.473***
	(0.057)	(0.052)
Constant	0.548***	0.846***
	(0.058)	(0.124)
Observations	36,183,256	36,183,256
Mean	0.5	0.5
Controls	X	X

Notes. Units of observation are directed dyads, based on the 54,850 non-Hispanic Black and non-Hispanic White students who reported GPAs and individual characteristics (age, gender, and race) from the in-school survey of the National Longitudinal Study of Adolescent to Adult Health. The dependent variable takes on the value of 1 if student i nominated student j as a friend. *dGPA* indicates a difference in average GPA between the pairs of students. *B* indicates Black students, and *W* indicates White students. *** $p < .01$, ** $p < .05$, * $p < .1$

Table B.5: Forming Friends and Difference in GPA: Semiparametric Low-Middle-High

| | Dependent variable : | |
| | i denoting j as a friend (%) | |
	(1)	(2)
$GPAi : low \times GPAj : middle \times BW$	0.086***	0.093***
	(0.018)	(0.024)
$GPAi : low \times GPAj : middle \times WB$	0.093***	0.081***
	(0.017)	(0.020)
$GPAi : low \times GPAj : middle \times BB$	0.046	0.057
	(0.044)	(0.039)
$GPAi : low \times GPAj : high \times BW$	0.187***	0.167***
	(0.032)	(0.034)
$GPAi : low \times GPAj : high \times WB$	0.241***	0.217***
	(0.035)	(0.034)
$GPAi : low \times GPAj : high \times BB$	0.107**	0.099**
	(0.052)	(0.039)
$GPAi : middle \times GPAj : low \times BW$	0.104***	0.090***
	(0.018)	(0.024)
$GPAi : middle \times GPAj : low \times WB$	0.080***	0.086***
	(0.020)	(0.026)
$GPAi : middle \times GPAj : low \times BB$	0.076*	0.084***
	(0.041)	(0.031)
$GPAi : middle \times GPAj : middle \times BW$	0.003	0.021
	(0.031)	(0.039)
$GPAi : middle \times GPAj : middle \times WB$	-0.001	0.018
	(0.033)	(0.038)
$GPAi : middle \times GPAj : middle \times BB$	0.076	0.094
	(0.097)	(0.078)
$GPAi : middle \times GPAj : high \times BW$	0.012	-0.008
	(0.047)	(0.043)
$GPAi : middle \times GPAj : high \times WB$	0.032	0.041
	(0.048)	(0.042)
$GPAi : middle \times GPAj : high \times BB$	0.230	0.204
	(0.173)	(0.139)
$GPAi : high \times GPAj : low \times BW$	0.248***	0.224***
	(0.033)	(0.033)
$GPAi : high \times GPAj : low \times WB$	0.179***	0.160***
	(0.033)	(0.035)
$GPAi : high \times GPAj : low \times BB$	0.090*	0.083**
	(0.051)	(0.038)
$GPAi : high \times GPAj : middle \times BW$	0.068	0.078*
	(0.047)	(0.040)
$GPAi : high \times GPAj : middle \times WB$	0.019	0.001
	(0.047)	(0.043)
$GPAi : high \times GPAj : middle \times BB$	0.153	0.131
	(0.151)	(0.117)

Table B.5: Friendship Formation by Race and Achievement: Semiparametric Low-Middle-High (Continued)

	Dependent variable : i denoting j as a friend (%)	
	(1)	(2)
$GPAi : high \times GPAj : high \times BW$	-0.207**	-0.229***
	(0.091)	(0.070)
$GPAi : high \times GPAj : high \times WB$	-0.209**	-0.229***
	(0.090)	(0.066)
$GPAi : high \times GPAj : high \times BB$	0.233	0.165
	(0.305)	(0.245)
$GPAi : low \times GPAj : middle$	-0.085***	-0.067***
	(0.015)	(0.009)
$GPAi : low \times GPAj : high$	-0.211***	-0.178***
	(0.030)	(0.020)
$GPAi : middle \times GPAj : low$	-0.098***	-0.087***
	(0.017)	(0.011)
$GPAi : middle \times GPAj : middle$	0.018	0.031**
	(0.028)	(0.015)
$GPAi : middle \times GPAj : high$	0.013	0.037**
	(0.045)	(0.016)
$GPAi : high \times GPAj : low$	-0.229***	-0.210***
	(0.032)	(0.024)
$GPAi : high \times GPAj : middle$	-0.005	0.014
	(0.044)	(0.015)
$GPAi : high \times GPAj : high$	0.307***	0.318***
	(0.090)	(0.050)
BB	0.173*	0.197*
	(0.101)	(0.118)
BW	-0.500***	-0.544***
	(0.061)	(0.055)
WB	-0.469***	-0.511***
	(0.061)	(0.055)
Constant	0.592***	0.877***
	(0.062)	(0.124)
Observations	36,183,256	36,183,256
Mean	0.5	0.5
Controls		X

Notes. Units of observation are directed dyads, based on the 54,850 non-Hispanic Black and non-Hispanic White students who reported GPAs and individual characteristics (age, gender, and race) from the in-school survey of the National Longitudinal Study of Adolescent to Adult Health. The dependent variable takes on the value of 1 if student i nominated student j as a friend. *dGPA* indicates a difference in average GPA between the pairs of students. *B* indicates Black students, and *W* indicates White students. Due to the size of table, I do not present variables with *WB* and *BW*. *** $p < .01$, ** $p < .05$, * $p < .1$

B.4 Including Hispanic Students

We examine whether including Hispanic students affects our results. We add Hispanic students to our analysis sample and additional variables indicating Hispanic students to the regression equation 1. The added variables are as follows: $B_i H_j$, $W_i H_j$, $H_i H_j$, $H_i W_j$, $H_i B_j$, $d_{ij} \times B_i H_j$, $d_{ij} \times W_i H_j$, $d_{ij} \times H_i H_j$, $d_{ij} \times H_i W_j$, and $d_{ij} \times H_i B_j$. As presented in Table B.6, including Hispanic students does not significantly affect the results. The difference in GPA matters similarly between pairs of Black students and pairs of White students ($dGPA \times BB$) and matters less between pairs of Black and White students ($dGPA \times BW$).

Table B.6: Friendship Formation by Race and Achievement: Including Hispanic

	Dependent variable : i denoting j as a friend (%)	
	(1)	(2)
$dGPA$	-0.216***	-0.195***
	(0.025)	(0.022)
$dGPA \times BB$	0.047	0.022
	(0.044)	(0.045)
$dGPA \times BW$	0.188***	0.163***
	(0.025)	(0.023)
$dGPA \times BH$	0.186***	0.158***
	(0.028)	(0.026)
$dGPA \times WB$	0.182***	0.160***
	(0.024)	(0.023)
$dGPA \times WH$	0.110***	0.104***
	(0.023)	(0.020)
$dGPA \times HH$	0.151***	0.117***
	(0.034)	(0.034)
$dGPA \times HW$	0.117***	0.107***
	(0.023)	(0.019)
$dGPA \times HB$	0.180***	0.152***
	(0.028)	(0.025)
BB	0.168	0.234
	(0.166)	(0.152)
BW	-0.624***	-0.612***
	(0.078)	(0.059)
BH	-0.541***	-0.324***
	(0.095)	(0.066)
WB	-0.597***	-0.587***
	(0.078)	(0.058)
WH	-0.360***	-0.261***
	(0.071)	(0.050)
HH	-0.427***	-0.060
	(0.132)	(0.074)
HW	-0.383***	-0.281***
	(0.070)	(0.048)
HB	-0.535***	-0.315***
	(0.094)	(0.067)
Constant	0.752***	0.876***
	(0.080)	(0.092)
Observations	53,008,910	53,008,910
Mean	0.433	0.433
Controls		X

Notes. Units of observation are directed dyads, based on non-Hispanic Black, non-Hispanic White, and Hispanic students who reported GPAs and individual characteristics (age, gender, and race) from the in-school survey of the National Longitudinal Study of Adolescent to Adult Health. *dGPA* indicates a difference in average GPA between the pairs of students. *B* indicates Black students, and *W* indicates White students. *H* indicates Hispanic students. *** $p < .01$, ** $p < .05$, * $p < .1$