Title: The Limits of Educational Attainment in Mitigating Occupational Segregation Between Black and White Workers

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Abstract: Past work has documented significant occupational segregation between Black and white workers in the U.S. labor force. Little work, however, has examined racial occupational segregation in recent years or by levels of education and then at the intersection of education and race. In this paper, we contribute to this literature by calculating a dissimilarity index to examine racial occupational segregation between 1980 and 2019, comparing Black and white workers with and without bachelor's degrees and by developing a Monte Carlo simulation, where we compare the observed levels of segregation to predicted levels of racial occupational segregation by education under race-neutral conditions. First, we find that considerable racial occupation segregation in the labor market persists today regardless of educational attainment and that observed segregation is substantially higher than would be expected at random, conditional on educational attainment, gender, and geography. We compare the types of occupations in which Black and white workers are disproportionately situated, and we show that this segregation has significant consequences for wage inequality between Black and white workers with and without four-year degrees. Overall, our results show that racial occupational desegregation has stalled in the past two decades despite rising educational attainment amongst Black workers.

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The social sciences have accumulated substantial evidence of labor-market racial inequities in wages, employment, and mobility (Bayer and Charles 2018; Chetty et al., 2020). A subset of this work has focused on racial occupational segregation – the degree to which members of different racial groups are distributed unequally across different types of jobs (Reskin and Cassirer 1996; Semyonov et al., 2000; Kaufman 2002; Queneau 2009; Mintz and Krymkowski 2010; Gradín 2013; del Río and Alonso-Villar 2015). Occupational segregation can have far reaching consequences on wages, mobility, and on beliefs about the value of certain jobs and who occupies them (Aneja and Xu 2022). Because few studies have examined recent levels of racial occupational segregation and fewer still have explored racial occupational segregation by education level (e.g., Spriggs and Williams 1996), we examine occupational segregation by race and education level over the last four decades.

We focus specifically on differences between Black and white workers, since historically and today, Blacks have been targets of racial prejudice and subject to significant forms of discrimination (Nunley et al., 2014; Pager and Shepherd 2008). We draw comparisons in occupational segregation between Black and white workers with a bachelor's degree and between workers with high school diplomas but not bachelor's degrees. Following previous research (Blair et al., 2020; Blair, Debroy, and Heck 2021), we refer to workers without a four-year degree as those "skilled through alternative routes" (STARs). This terminology was created, in part, to both recognize and empirically quantify the reality that workers gain valuable employable skills through other pathways and not only through the bachelor's degree. The STARs terminology, moreover, shifts away from marginalizing, deficit-based rhetoric that describes workers relative to a credential that they do not possess towards an asset-based rhetoric that highlights the skills they do possess (Baldridge 2014). By definition, STARs are aged 25 or

older, active in the labor force, have a high school diploma or equivalent, and have developed their skills through routes other than a four-year diploma such as community college, apprenticeships, and work experience (Opportunity@Work and Accenture 2020; Blair et al., 2020). They compose more than half of the civilian, non-institutionalized labor market.

Our motivations for describing the contemporary state of racial occupational segregation are twofold. First, many prior studies considered the state of the labor market in the latter half of the twentieth century before significant policy changes and generational turnover that may have affected occupational segregation in the ensuing decades. Second, academics, policymakers, and practitioners have long touted rising education levels among people of color as a solution to racial inequality in the labor market, including occupational segregation (Gradín 2013; Zhavoronkova, Khattar, and Brady 2022). As more Black Americans earn bachelor's degrees, the assumption has been that they should subsequently have access to the same types of higher-paying jobs as college-educated whites, thereby reducing racial occupational segregation and wage inequality in the labor market. Building on prior work (Spriggs and Williams 1996; Hellerstein and Neumark 2008), we empirically test both the degree to which college may fail to eliminate racial occupational segregation among similarly situated workers and the degree to which segregation may persist among the sizeable share of STARs in the workforce.

Drawing on data from the U.S. Census and the American Community Survey, we use a dissimilarity index to compare the degree of racial occupational segregation in the labor market by education levels in each decade between 1980 and 2019. Our work extends the work of Spriggs and Williams (1996), who focused on occupational segregation by education and race from 1940 to 1980, and builds on it by introducing a Monte Carlo simulation that we use to estimate the predicted level of occupational segregation by race and educational status in a

race-neutral labor market. We find that significant racial occupational segregation exists in 2019, and while segregation has slightly declined since 1980, it has also increased somewhat since 2000. Furthermore, while racial occupational segregation is especially pronounced among STARs, it also persists across education groups, contrary to conventional expectations. Our simulation results predict that segregation is substantially higher than would be expected at random, conditional on educational attainment, gender, and geography. These findings are consistent with our argument that rising levels of education do not necessarily eliminate occupational segregation and with our claim that aggregate views of the labor market mask consequential and persistent inequalities, particularly among STARs.

We proceed as follows. First, we review prior research on occupational segregation over time and the consequences of this segregation for workers. Then, we discuss extant theories about the causes of this segregation. We consider both supply-side explanations—which focus on the characteristics and preferences of workers—and demand-side explanations—which attend to the preferences, behaviors, and beliefs of employers. From there, we examine occupational segregation by race and education between 1980 and 2019 and consider the consequences for wage differences. We end by discussing the implications of our findings.

The Legacy and Consequences of Occupational Segregation

Historically, occupational segregation between Black and white workers in the U.S. has been significant and persistent. After Emancipation, Black Americans labor market choices were limited to menial jobs, and in the South, they were formally segregated for nearly half a century by the draconian system of Jim Crow (Reskin and Padavic 2006). During the Presidency of Woodrow Wilson, large parts of the federal government that were integrated were re-segregated,

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with long-lasting negative consequences on wages and home ownership for Black workers and families (Aneja and Xu 2022). Before the 1960s, white men nearly monopolized most professional, technical, and managerial jobs. In the 1960s and 1970s, as key civil rights legislation was passed and the Equal Employment Opportunity Commission (EEOC) was established, racial and ethnic minorities gained access to a wider array of occupations. But over time, as political pressure for racial equality receded and the EEOC's ability to monitor employment practices weakened, occupational integration stalled (del Río and Alonso-Villar 2015; Semyonov et al., 2000). With this historical backdrop, it is important for researchers to quantify the level of racial segregation and to disaggregate the data further to measure the extent to which occupational segregation by race and educational attainment today encodes historic practices of funneling Black workers away from roles of leadership, responsibility, and opportunity for mobility.

In an analysis of data on workers in 1990, Kaufman (2002) found that almost one-third of Black or white workers would have had to change occupations to achieve full racial integration. By 2002, workplace desegregation for Blacks was at the same levels it had been in 1980 (Tomaskovic-Devey et al., 2006; Tomaskovic-Devey & Stainback 2007; although, see Queneau 2009). Segregated occupations significantly depress the wages of Black workers who, compared to white workers, are relegated to poorly compensated, less desirable jobs (Hirsch and Schumacher 1992; Kmec 2003; Browne et al. 2001; Reskin, McBrier, and Kmec 1999; King 1992; Tomaskovic-Devey 1993; Hamilton, Austin, and Darity 2011). This relegation creates a feedback loop: because society sees the people who hold these positions as inherently less valuable, the jobs they occupy are in turn seen as less valuable, and the workers in these positions are then therefore poorly compensated (Petersen and Saporta 2004). As Reskin and

Padavic wrote, "job segregation is the linchpin in workplace inequality because the relegation of different groups to different kinds of work both facilitates and legitimates unequal treatment" (2006: 344).

Occupational segregation also has consequences for hierarchies of authority, creating both "glass ceilings" and "sticky floors" where Blacks are excluded from more desirable high-status jobs and confined to low-status positions (Reskin and Padavic 2006). This vertical segregation limits Black workers' upward mobility and access to higher wages (Kluegel 1978; Elliott and Smith 2004).

Labor Supply-Side Explanations for Racial Occupational Segregation

There are several explanations for racial occupational segregation. We focus first on supply-side accounts, which emphasize the preferences, skills, and qualifications workers bring to the labor market. Particularly relevant is Becker's theory of human capital, which argues that workers seek skills acquisition, including formal education, on-the-job-training, and job experience when they expect these investments will generate a positive return in wage and job prospects (Becker 1957, 1994). The centrality of education in the popular imagination as the key to upward mobility has promoted the pervasive argument that existing labor market inequality is the result of educational inequality. Therefore, racial equality in the labor market can be achieved through raising rates of college education among Black Americans (Krymkowski and Mintz 2011; Wilson 1980).

Over the past several decades, Black Americans have made significant gains in four-year degree completion rates. Between 2000 and 2019 alone, the percentage of Black workers with a bachelor's degree rose from 18.9 percent to 28.3 percent.[1] The expectation from the supply-side

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[1] Analysis of data from the 2000 Decennial Census and the 2019 1-year American Community Survey, accessed via IPUMS. The sample is limited to workers 25 years or older who were active in the civilian labor force.

perspective, therefore, is that the overall level of occupational segregation should decrease commensurate with rising levels of Black educational attainment. While there is some evidence that a reduction of the racial gap in educational attainment contributed to the occupational integration of Black workers between 1940 and 1990 (King 1992), there are clearly limits to the degree to which investments in human capital can attenuate occupational segregation and foster labor market equality. After 1990, educational attainment appears to have played little to no role in occupational segregation by race (Reskin and Padavic 2006; Krymkowski and Mintz 2011). Even after accounting for education, prior work finds that at least until 2002, whites continued to enter occupations with higher wages and levels of authority at greater rates than people of color (Mintz and Krymkowski 2010).

Workers do not have complete autonomy to choose their productivity characteristics. Discrimination, environmental racism, unequal access to quality K-12 education, and racial disparities in incarceration rates can also reduce Black Americans' ability to invest in human capital (Haggerty and Johnson 1995; Diamond 2006; Harding, Morenoff, and Wyse 2019). Furthermore, the majority of the Black labor force (60 percent) is concentrated in the U.S. South where job opportunities are relatively more limited and racism is more prominent (Hancock et al., 2021; Airstrup 2011). Finally, some speculate that worker preferences for types of work and a desire to avoid discrimination can produce occupational segregation. To the contrary, however, research finds that compared to white job-seekers, Black Americans looking for employment search for positions with a greater range of qualities and across a broader set of categories (Pager and Pedulla 2015).

We also note that the focus on human capital investment as a solution to occupational segregation and other forms of labor market inequality necessarily addresses future, rather than

present, racial disparities. The growing rates of college attainment have occurred primarily among young Black Americans just entering the workforce, but there is a sizable talent pool of Black workers already in the labor market for whom a return to college would be impractical. As of 2019, there were 11 million Black workers without bachelor's degrees in the labor market, and they comprise the majority–almost two-thirds–of all Black workers. Thus, while there is clear evidence that the human capital gained in college can lead to higher individual and aggregate productivity (Moretti 2004), college as a solution to labor market inequities primarily works through gradual generational replacement and excludes most of the existing Black workforce. It is therefore especially important to consider the state of the labor market as it applies to both workers with and without bachelor's degrees.

Labor Demand-Side Explanations for Racial Occupational Segregation

A more robust literature has examined demand-side explanations, which consider the characteristics of the job, employer preferences, and the workplace, for occupational segregation. Much of this work focuses on the behavior of employers and their motivation to discriminate racially. There is much evidence that racial discrimination in the labor market is widespread and persistent (Quillian et al., 2017). Racial discrimination offers a compelling explanation for why supply-side theories are often insufficient explanations for racial inequality in the labor market, including racial occupational segregation.

Historically, research shows that employers often make hiring and promotion decisions based on erroneous stereotypes about groups (Arrow 1973; Tomaskovic-Devey 1993), and for Blacks in particular, based on pervasive and harmful stereotypes about deficits in work ethic and dependability (Schuman et al., 1985; Kirschenman and Neckerman 1991; Moss and Tilly 2001).

Based on these pernicious beliefs about the qualities of Black applicants, employers may be reluctant to hire or promote Black workers, or willing only to hire them for menial jobs (Greenhaus, Parasuraman, and Wormley 1990).

The intersection of racial stereotypes about employees and occupational stereotypes about who is appropriate for particular positions generates a reinforcing cyclical relationship: employers' stereotypes about Black workers' capabilities develop from their observations about where Black workers are employed and the skills they therefore possess. These stereotypes reinforce occupational stereotypes about who is best suited to perform particular tasks. Tasks for Black workers become those that involve physical labor, menial tasks, and poor working conditions, while work for whites involve high skills and more authority (Kaufman 2002).

The theory of social closure posits that white people actively seek to preserve their positions of dominance in the labor force by excluding people of color (Tomaskovic-Devey 1993; Wilson 1980). In the current labor market, in which white people hold 72.6 percent of managerial positions[2], white Americans are able to "opportunity hoard", favoring other whites in securing jobs protected from market competition (DiTomaso 2013). Exclusionary behaviors occur more in desirable jobs, so that as job desirability increases, the percentage of women or Black people decreases (Tomaskovic-Devey 1993). Furthermore, certain industries, including construction, other building trades, and skilled manufacturing occupations, have a history of exceptional opportunity hoarding that have limited Black workers' – particularly those without a bachelor's degree – access to well-paying jobs. The industry's reliance on informal social networks for hiring, coupled with a history of institutional resistance to Black union membership, have significantly limited Blacks' access to these occupations (Waldinger and Bailey 1991; Pallais and Sands 2016).

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[2] Analysis of data from the 2019 1-year ACS.

In addition, Americans' social networks tend to be overwhelmingly composed of people of the same race or ethnic background (Cox, Navarro-Reivera, and Jones 2016). Because many individuals secure jobs through referrals and personal connections, segregated social networks may also perpetuate occupational segregation (Fernandez and Fernandez-Mateo 2006; Bayer, Ross, and Topa 2008). Despite using their networks at similar rates while job seeking, network-based methods are less likely to lead to job offers for Black workers (Pedulla and Pager 2019).

Examining Racial Occupational Segregation by Education

Given the limits of human capital theory, especially the persistence of discrimination in the labor market, we examine occupational segregation by race and education over time. We test whether occupational segregation between Black and white workers is as similar in magnitude among workers with a bachelor's degree as it is among workers who do not have a bachelor's degree (STARs). Using a Monte Carlo simulation, we also calculate predicted levels of racial occupational segregation by education under race-neutral conditions. We hypothesize that observed racial occupational segregation is greater than it would be if workers were randomly distributed in the labor market.

We then examine the occupations where Black and white workers with and without bachelor's degrees are primarily situated both by volume and by the proportion of these workers within occupations. Our hypothesis is that within education groups, not only are Black and white workers located in different occupations, but also that the median wages for Black workers are lower than they are for occupations where there are more whites or in which whites are overrepresented.

Data

The data we employ come from the 1980, 1990, and 2000 U.S. Decennial Censuses and the 2010

and 2019 1-year American Community Survey (ACS), accessed via the University of Minnesota

Integrated Public Use Microdata Series (IPUMS). These data allow us to observe changes in the

labor force by race and education levels over 39 years. We limit our analysis to employed adults

aged 25 and older in the civilian, non-institutionalized labor force, excluding active-duty military

and residents of nursing homes or correctional facilities.[3] In 2019, our analyzed population

included 144 million individuals, of which 39% are workers with a bachelor's degree or higher,

53% are STARs (who have a high school diploma or equivalent, but not a bachelor's degree),

and 8% do not have a high school diploma or equivalent. Black workers are those who identified

their race as Black alone and their ethnicity as non-Hispanic: this population includes 17 million

individuals, of whom 65% are STARs.[4] In order to retain consistent occupational categories

across time, we use the IPUMS 2010 harmonized occupational coding scheme, which is based on

the Census Bureau's 2010 ACS occupation classification scheme and includes 422 occupations

in 2019.[5]

Measuring Occupational Segregation Across Time using a Dissimilarity Index

We begin by examining the degree of occupational segregation in the labor market by race and

education. We follow prior literature in using the index of dissimilarity (D), which measures

how evenly individuals are distributed among units (e.g., neighborhoods, schools, occupations),

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[3] We note that Black Americans, and especially Black Americans without bachelor's degrees, are overrepresented in some of these excluded categories.

[4] This definition excludes 526k workers who identified as both Black and Hispanic and 1.2 million workers who identify as multi-racial.

[5] Although this coding scheme has 493 occupations, not all of these occupation codes are used in a given year. There are 351 occupations in the 1980 and 1990 Decennial Censuses, 447 occupations in the 2000 Decennial Census, 449 occupations in the 2010 1-year ACS and 422 occupations in the 2019 1-year ACS.

as our measure of occupational segregation. Duncan and Duncan (1955) formulate the index, which is bounded by 0 (no segregation) and 1 (perfect segregation), as:

$$D \;=\; \frac{1}{2}\sum_{j=1}^{J}\left|\frac{n_j^1}{n^1}-\frac{n_j^0}{n^0}\right|$$

where there are $j \;=\; 1, \,..., \, J$ occupations in the labor market and all individuals $i \;=\; 1, \,..., \, n$ are in either group, $g \;=\; \{0, \, 1\}$. Although this measure has some limitations–namely small unit bias–it is a well understood and easy to interpret measure of segregation between two groups. In the context of the labor market, the dissimilarity index D represents the proportion of one group that would need to change occupations in order for the two groups to be evenly represented across each occupation.

In Table 1, we make four comparisons, calculating the dissimilarity index by degree status (STARs and workers with a bachelor's degree), race, and race within degree status in 1980, 1990, 2000, 2010, and 2019. First, we make comparisons by education. The dissimilarity index between STARs and workers with a bachelor's degree or higher in 2019 was 0.543. Therefore, 54.3% of STARs (or workers with a bachelor's degree) would need to change occupations for these two groups of workers to be evenly distributed across all occupations. Furthermore, this value has remained near constant over the period we examine, fluctuating by no more than 0.011.

Next, we make comparisons by race. The dissimilarity index in 2019 was 0.276. Therefore 27.6% of Black workers (or white workers) would need to change occupations for the two groups of workers to be evenly distributed across all occupations. Over the period from 1980 to 2019, the dissimilarity index dropped from 0.306 in 1980 to 0.270 in 1990 and has remained at this level for the following three decades – varying by 1 percentage point from this baseline in

2000, 2010 and 2019. This result stands in contrast to the substantial reductions in the dissimilarity index observed between white workers and Black workers from 1960-1980 (Spriggs and Williams 1996).[6]

	Dissimilarity Index (*D*)				
	1980	*1990*	*2000*	*2010*	*2019*
STARs - Bachelor's degree	0.543	0.532	0.547	0.543	0.543
Black - White	0.306	0.270	0.269	0.259	0.276
STARs: Black - White	0.307	0.268	0.249	0.256	0.278
Bachelor's degree: Black - White	0.279	0.234	0.217	0.210	0.221

Table 1. Occupational segregation over time by race and degree status. The index of dissimilarity measures how evenly workers are distributed within the 422 occupations in the 2010 harmonized occupations codes created by University of Minnesota Integrated Public Use Microdata Series (IPUMS). The population of interest is workers who are aged 25 or older and active in the labor force. Workers skilled through alternative routes (STARs) have a high school diploma or equivalent and have developed their skills through routes other than a four-year diploma such as community college, apprenticeships, bootcamps, and, most commonly, on-the-job work experience. Data are from the 1980, 1990, and 2000 U.S. Decennial Censuses and the 2010 and 2019 1-year American Community Surveys (ACS) accessed through IPUMS.

The conjecture that occupational segregation by race is largely the result of differences in college attainment between Black and white workers suggests that racial occupational segregation should be significantly smaller between Black and white workers with the same level of education than between Black and white workers in the aggregate. Additionally, we might expect that racial occupational segregation should be smaller among workers with bachelor's degrees than STARs because the bachelor's degree provides employers a clearer or more

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[6] From 1960-1980, the dissimilarity index between white and black women fell by 31 p.p., while the dissimilarity index between black men and white men fell by 11 p.p.

frequently recognized signal of skill (Arcidiacono, Bayer, and Hizmo 2010). We investigate these hypotheses directly in the second half of Table 1 in which we present the dissimilarity index between Black and white workers separately among STARs and workers with bachelor's degrees or higher.

For both STARs and workers with a bachelor's degree or higher, the dissimilarity index declined from 1980 to 2000 by about 6 percentage points and then, in the two decades since, it has either remained relatively constant or increased slightly. There is little evidence to suggest that racial occupational segregation between Black and white workers is primarily due to differences in educational attainment. In every decade since 1980, racial occupational segregation between Black and White STARs is no different from the level of racial occupational segregation among all workers. We find that compared to STARs, Black and white workers with bachelor's degrees are somewhat more integrated, but not by much. In 2019, nearly one-quarter (22.1%) of Black (or white) workers with a bachelor's degree or more would need to change occupations for full integration between these groups. College does appear to reduce racial occupational segregation, but our analysis shows that the effects are limited: racial occupational segregation is 3 to 5 percentage points (10 to 20 percent) lower among workers with a bachelor's degree than it is between Black and white STARs.[7]

Monte Carlo Simulations of Racial Occupational Segregation

In order to understand how much of the observed occupational segregation would occur under race-neutral conditions, we use Monte Carlo simulation to estimate the distribution of the dissimilarity index conditional on education, geography, and gender. Comparing the dissimilarity

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[7] While there is variation in educational attainment within the two education categories used here, occupational segregation by race is stable over time using more detailed education subcategories within the categories of STARs and workers with a bachelor's degree or more. See Appendix A2 for more details.

indices from our simulations to the dissimilarity indices from the real-world data offers a non-parametric approach for bounding the marginal impact of education in reducing occupational segregation by race that is complementary to the parametric approach pioneered in Spriggs and Williams (1996).

For each year, we conduct 10,000 Monte Carlo realizations in which respondents are first assigned occupations based on probability distributions generated from similarly-educated workers of the same gender in their geographic region. For STARs, the probability of respondent i of gender g in region r being assigned to any occupation $j = 1, ..., J$ is equal to:

$$Pr(j) = \frac{n^{STAR}_{j,g,r}}{n^{STAR}_{g,r}}$$

where $n^{STAR}_{j,g,r}$ is equal to the weighted total number of STARs in occupation j of gender g in region r and $n^{STAR}_{g,r}$ is the weighted total number of STARs of gender g in region r. For workers with a bachelor's degree or higher, the probability of respondent i of gender g in region r being assigned to any occupation $j = 1, ..., J$ is equal to:

$$Pr(j) = \frac{n^{BD}_{j,g,r}}{n^{BD}_{g,r}}$$

where $n^{BD}_{j,g,r}$ is equal to the weighted total number of workers with a bachelor's degree or higher in occupation j of gender g in region r and $n^{BD}_{g,r}$ is the weighted total number of workers with a bachelor's degree or higher of gender g in region r.

After all respondents have been assigned an occupation, we use the person-level survey weights to calculate the total number of workers by race and education in each occupation before using the simulated occupation-level totals to recalculate the dissimilarity index, D. For an

example of the resulting distributions of *D*, Figure 1 shows the distribution of the simulated

dissimilarity index separately for STARs and workers with a bachelor's degree in 2019.
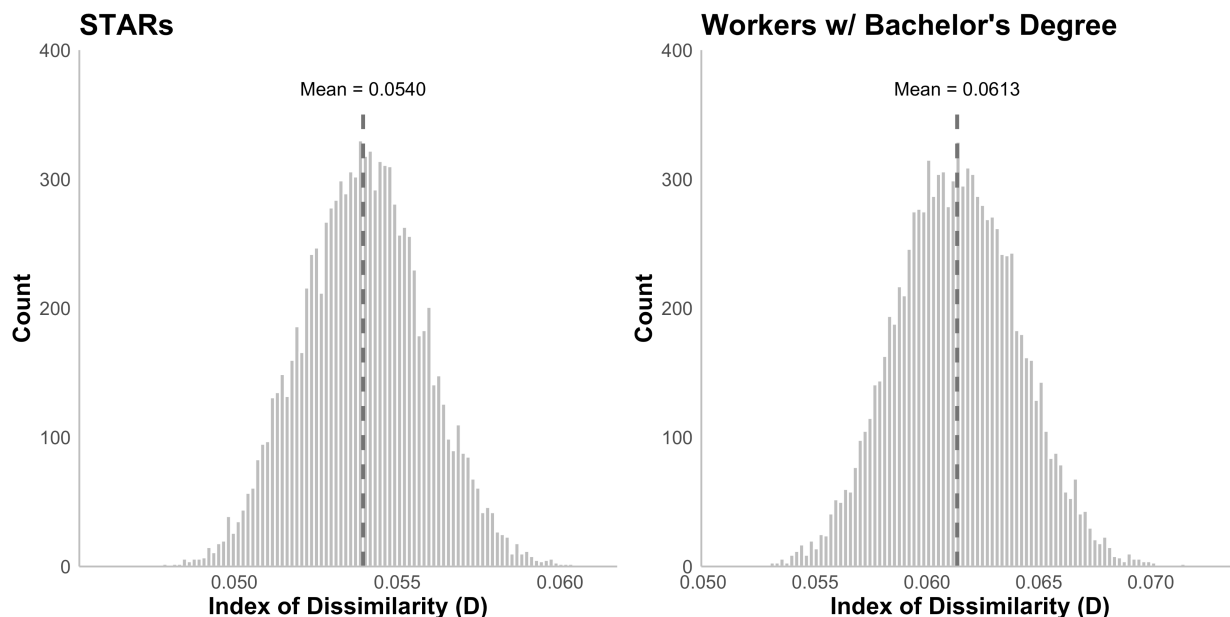
Figure 1. Distribution of Simulated Dissimilarity Index, 2019. Dissimilarity indices between Black and white workers by educational attainment over 10,000 Monte Carlo simulations. Occupational assignment probabilities are conditional on a worker's education, gender, and geographic region. The index of dissimilarity measures how evenly workers are distributed within the 422 occupations in the 2010 harmonized occupations codes created by University of Minnesota Integrated Public Use Microdata Series (IPUMS). Data are from the 2019 1-year American Community Surveys (ACS) accessed through IPUMS.

In Table 2, we present the results from our Monte Carlo simulation. Since we condition

on gender and educational status but not race, our simulation results for the levels of

occupational segregation by education and gender should match what we find in the

observational data. Indeed, we find a close match, to within one percentage point, between the

simulated and observed dissimilarity indices by gender and education – giving us confidence that

our simulation is working as designed. After controlling for education, gender, and geography,

workers have the same probability of assignment to any occupation regardless of race. Therefore,

Index of Dissimilarity (*D*)

		1980	*1990*	*2000*	*2010*	*2019*
Observed	STARs - Bachelor's	0.543	0.532	0.547	0.543	0.543
	Women - Men	0.585	0.524	0.515	0.505	0.483
	STARs: Black - White	0.307	0.268	0.249	0.256	0.278
	Bachelor's: Black - White	0.279	0.234	0.217	0.210	0.221
Simulated	STARs - Bachelor's	0.546 [0.545, 0.547]	0.532 [0.531, 0.533]	0.550 [0.549, 0.551]	0.543 [0.541, 0.545]	0.541 [0.539, 0.543]
	Women - Men	0.588 [0.588, 0.589]	0.529 [0.528, 0.530]	0.522 [0.521, 0.523]	0.512 [0.510, 0.514]	0.487 [0.485, 0.489]
	STARs: Black - White	0.056 [0.054, 0.057]	0.042 [0.041, 0.044]	0.044 [0.043, 0.046]	0.054 [0.051, 0.057]	0.054 [0.050, 0.058]
	Bachelor's: Black - White	0.110 [0.107, 0.114]	0.073 [0.070, 0.077]	0.063 [0.060, 0.066]	0.070 [0.064, 0.075]	0.061 [0.056, 0.067]

Table 2. Monte Carlo simulations of racial occupational segregation by educational attainment. Reported values are the average dissimilarity index over 10,000 Monte Carlo simulations, with 95 percent confidence intervals included in brackets. The index of dissimilarity measures how evenly workers are distributed within the occupations in the 2010 harmonized occupations codes created by University of Minnesota Integrated Public Use Microdata Series (IPUMS). The population of interest is workers who are aged 25 or older and active in the labor force. Workers skilled through alternative routes (STARs) have a high school diploma or equivalent and have developed their skills through routes other than a four-year diploma such as community college, apprenticeships, bootcamps, and, most commonly, on-the-job work experience. Data are from the 1980, 1990, and 2000 U.S. Decennial Censuses and the 2010 and 2019 1-year American Community Surveys (ACS) accessed through IPUMS.

the simulated values of the dissimilarity index between Black and white STARs and Black and white workers with bachelor's degrees reflect the extent of occupational segregation under conditions of a race-neutral labor market. It is important to note that since we are taking the

racial distribution of workers by education level within a region to be fixed, in our simulation results, we are not asserting a race-neutral education market.

There are two surprising findings from our simulation. The first is that the level of occupational segregation for both STARs and workers with bachelor's degrees is substantially lower in a race-neutral labor market. The dissimilarity index for STARs falls by 20 to 25 percentage points relative to the observed value, and the dissimilarity index for workers with bachelor's degrees falls by 14 to 18 percentage points. Decreases in the dissimilarity index of these magnitudes are comparable to the precipitous drops in the dissimilarity index that occurred naturally in the observational data reported by Spriggs and Williams (1996) from 1940-1980. Indeed, racial considerations, or at least factors correlated with race other than a worker's education, geography, or gender, are substantially important for understanding occupational segregation between Black and white workers.

The signaling model of human capital would suggest that there would be less occupational segregation between Black workers and white workers with college degrees than Black and white STARs since the education credential would reduce the propensity for firms to engage in statistical discrimination on the basis of race (Arcidiacono, Bayer, and Hizmo 2010). Our second finding, however, which is perhaps more surprising than the first, is that the simulated level of occupational segregation by race is lower for STARs (0.042 to 0.056) than it is for workers with bachelor's degrees (0.063 to 0.110). In the observational data, the reverse was true, with there being a higher level of occupational segregation by race for STARs than for workers with bachelor's degrees. Because the confidence intervals from our simulation are narrow, we can reject the null hypothesis that the level of occupational segregation faced by STARs is the same as that faced by workers with bachelor's degrees. Moreover, for STARs, the

drop in the level of occupational segregation that occurs from removing considerations for race in the simulations is several times larger than the reduction in the level of occupational segregation in the observational data that occurs between STARs and workers with bachelor's degrees (3 p.p. versus 20 p.p.).

The Occupations and Wages of Black and White Workers

Having demonstrated that racial occupational segregation remains significant in the contemporary U.S. labor market across levels of education and is much higher than one would predict by random chance, we next consider the landscape of this segregation. We both examine the types of occupations in which Black and white STARs and workers with a bachelor's degree are primarily employed and the occupations in which segregation is the greatest. We also explore the implications of this segregation on wage disparities.

We begin by comparing the highest volume occupations for Black and white STARs and Black and white workers with bachelor's degrees. Figure 2 presents the distribution of Black and white STARs, as well as Black and white workers with bachelor's degrees, in the top ten occupation categories with the greatest number of workers. We find that Black STARs are predominantly employed as nursing and home health aides, delivery truck drivers, customer service representatives, janitors, and laborers and freight movers. By contrast, white STARs are principally employed as supervisors of sales workers and other managers, a pattern consistent with prior research on racial occupational segregation, which showed evidence that Black workers were often precluded from positions of authority in the U.S. labor market (Aizer et. al. 2020).
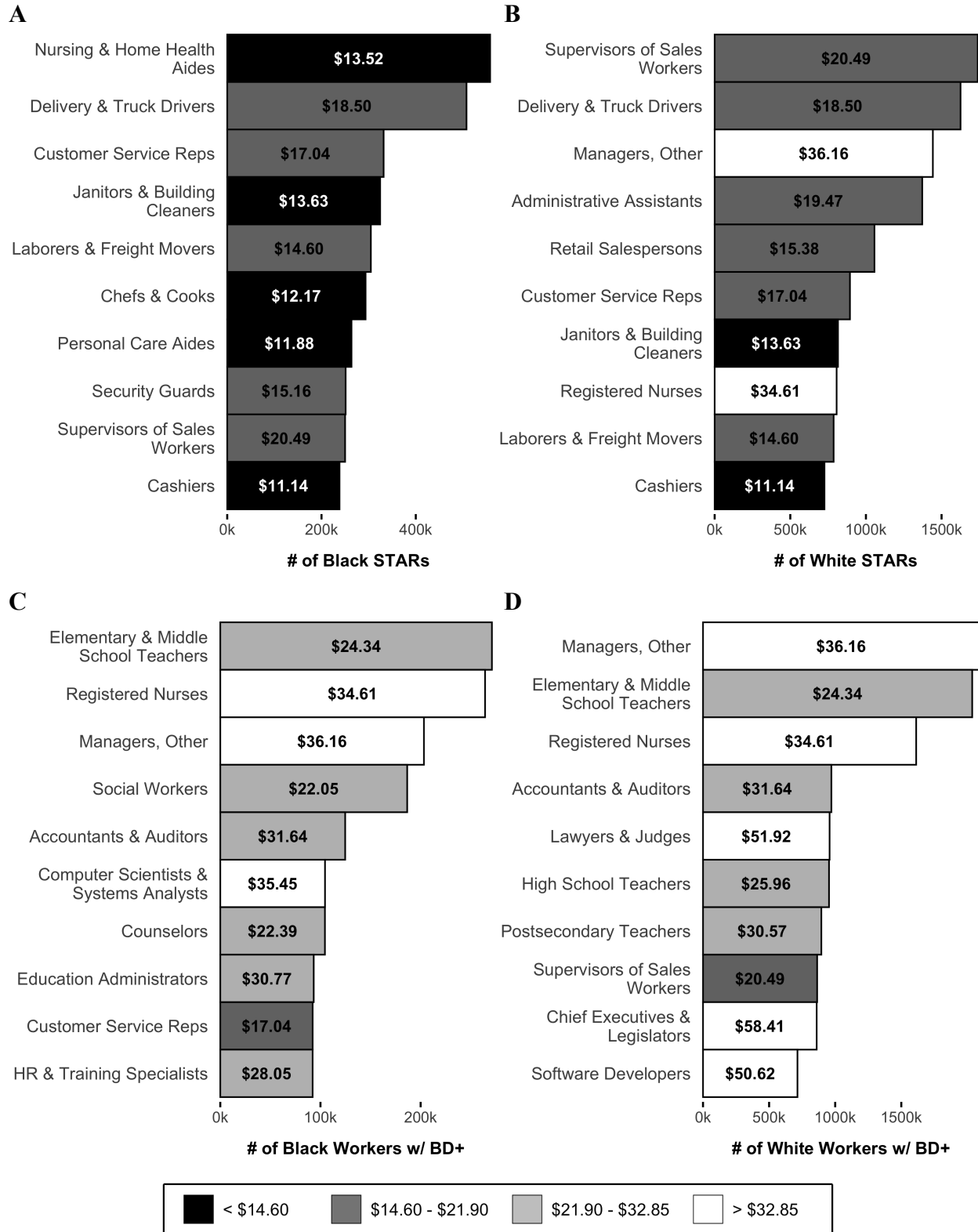
A

Occupation	Wage
Nursing & Home Health Aides	$13.52
Delivery & Truck Drivers	$18.50
Customer Service Reps	$17.04
Janitors & Building Cleaners	$13.63
Laborers & Freight Movers	$14.60
Chefs & Cooks	$12.17
Personal Care Aides	$11.88
Security Guards	$15.16
Supervisors of Sales Workers	$20.49
Cashiers	$11.14

# of Black STARs

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Occupation	Wage
Supervisors of Sales Workers	$20.49
Delivery & Truck Drivers	$18.50
Managers, Other	$36.16
Administrative Assistants	$19.47
Retail Salespersons	$15.38
Customer Service Reps	$17.04
Janitors & Building Cleaners	$13.63
Registered Nurses	$34.61
Laborers & Freight Movers	$14.60
Cashiers	$11.14

# of White STARs

C

Occupation	Wage
Elementary & Middle School Teachers	$24.34
Registered Nurses	$34.61
Managers, Other	$36.16
Social Workers	$22.05
Accountants & Auditors	$31.64
Computer Scientists & Systems Analysts	$35.45
Counselors	$22.39
Education Administrators	$30.77
Customer Service Reps	$17.04
HR & Training Specialists	$28.05

# of Black Workers w/ BD+

D

Occupation	Wage
Managers, Other	$36.16
Elementary & Middle School Teachers	$24.34
Registered Nurses	$34.61
Accountants & Auditors	$31.64
Lawyers & Judges	$51.92
High School Teachers	$25.96
Postsecondary Teachers	$30.57
Supervisors of Sales Workers	$20.49
Chief Executives & Legislators	$58.41
Software Developers	$50.62

# of White Workers w/ BD+

Legend: ■ < $14.60 | ▨ $14.60 - $21.90 | ▨ $21.90 - $32.85 | □ > $32.85

Figure 2. Top ten largest occupations by race and education. Occupations are classified into wage groups using the OECD wage level thresholds such that workers in low wage occupations earn less than two-thirds of national median hourly wages (less than $14.42), workers in middle wage occupations earn

between two-thirds and one-and-a-half times median hourly wages ($14.42 - $32.45), and workers in high wage occupations earn more than one-and-a-half times median hourly wages (more than $32.45). Wages are reported in 2020 dollars. Data are from the 2019 1-year American Community Survey (ACS) accessed through the University of Minnesota Integrated Public Use Microdata Series (IPUMS).

When we compare Black and white workers with a bachelor's degree by volume, we see more overlap in the types of occupations where many of these workers are employed. Both groups are employed as elementary and middle school teachers, registered nurses, and accountants and auditors. But the figure also reveals some notable differences. For one, a sizable number of Black workers with bachelor's degrees have positions as social workers or counselors. Neither of these roles, in contrast, appears in the list of top ten positions for white workers with a bachelor's degree. White workers with a bachelor's degree are also more frequently employed as lawyers and judges, high school teachers, postsecondary teachers, supervisors of sales workers, and chief executives and legislators—all positions of greater authority and none of which appear on the list of top ten jobs for Black workers with a bachelor's degree.

Sorting occupations by the number of Black and white STARs employed also provides important insight into wage differences. We first classify each occupation into wage groups using the Organization for Economic Co-operation and Development (OECD) wage level thresholds, such that workers in low wage occupations are those that earn less than two-thirds of national median hourly wages (less than $14.42), workers in middle wage occupations earn between two-thirds and one-and-a-half times median hourly wages ($14.42 - $32.45), and workers in high wage occupations earn more than one-and-a-half times median hourly wages (more than $32.45). Because of the distribution of occupational median wages and the width of the middle wage category, this classification scheme classifies 293 occupations, or 63%, as middle wage. As a result, we split this category such that workers in lower-middle wage occupations earn between

two-thirds times median and median hourly wages ($14.42 - $21.90) and workers in upper-middle wage occupations earn between median and one-and-a-half time median hourly wages ($21.90 - $32.45).[8] We report wages in 2020 dollars.

As we can see from Figure 2, none of the top ten jobs in which Black STARs are employed by volume are considered high-wage. Meanwhile, five out of the ten are low-wage, and all ten pay less than the national median. By comparison, among the top ten jobs for white STARs by volume, only two are low wage, six are lower-middle wage, and two are high wage. Most strikingly, we find that 76.9% of Black STARs work in occupations with hourly wages less than the national median wage and 29.3% of Black STARs are in low wage occupations. In contrast, 62.8% of white STARs work in occupations that pay less than the national median wage and 16.8% of white STARs are in low wage occupations. These differences are substantial: the share of workers with hourly wages below the national median is 14.1 percentage points higher among Black STARs than among white STARs. Similarly, the share of Black STARs in low wage occupations is 12.5 percentage points higher than the share of white STARs.

Although all workers with bachelor's degrees are significantly more likely than STARs to be in upper-middle or high wage occupations, occupational segregation and wage disparity between racial groups persists at this higher level of education. For example, 70.4% of Black workers with a bachelor's degree or higher are in occupations that earn more than the national median wage, and 29.3% are in high wage occupations. In contrast, 78.5% of white workers with a bachelor's degree or higher are in occupations earning more than the national median wage and 39% are in high wage occupations. Of the top ten jobs by volume for Black workers with a bachelor's degree, only three are high-wage. Among the top ten occupations by volume for

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[8] Based on this classification, 17% of occupations are classified as low wage, 35% as lower-middle wage, 27% as upper-middle wage, and 21% as high wage.
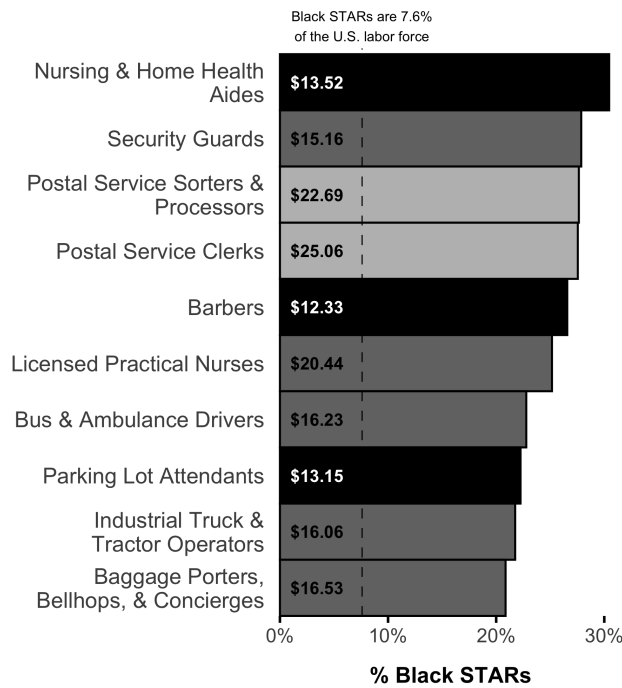
whites with bachelor's degrees, we can see that five of the ten occupations are high-wage, four are upper-middle wage, and one is lower-middle wage.

Examining high volume occupations provides important insight into how racial groups by education levels are distributed across the entire labor market, but this approach also limits our insight into the landscape of occupational segregation; namely, it does not reveal whether there are some jobs in which Black or white workers are markedly overrepresented or overwhelmingly excluded. We therefore examine occupations by the proportion of workers who are Black or white STARs or Black or white workers with college degrees. As we did in the previous analysis, we sort these occupations in descending order by the percent of each type of worker in the occupation and present the results in Figure 3. For each panel in Figure 3, the vertical dashed line represents the share of the group in the overall population. The extent to which the bars extend beyond that line therefore indicates the degree to which a group is overrepresented in each occupation.
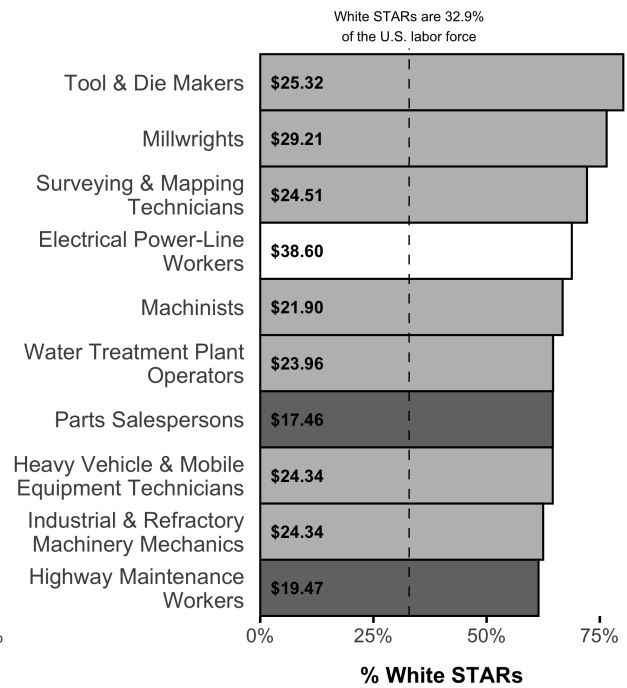
There are several important insights we can glean from viewing occupations in this way. First, we can see that Black STARs are especially disproportionately represented in some occupations. Despite making up about 7.6% of the U.S. labor force in 2019, in the ten occupations in the first panel of Figure 3, Black STARs compose more than 20% of workers. Nursing and home health aides, security guards, postal sorters and clerks, barbers, and licensed practical nurses are disproportionately Black STARs. What is more, three out of ten of these positions are considered low-wage and five are lower-middle wage.

By comparison, white STARs are disproportionately represented in jobs as tool and die makers, millwrights, surveying and mapping technicians, electrical power-line workers, and machinists. In most of these positions, white STARs compose more than 60%–and in some cases,
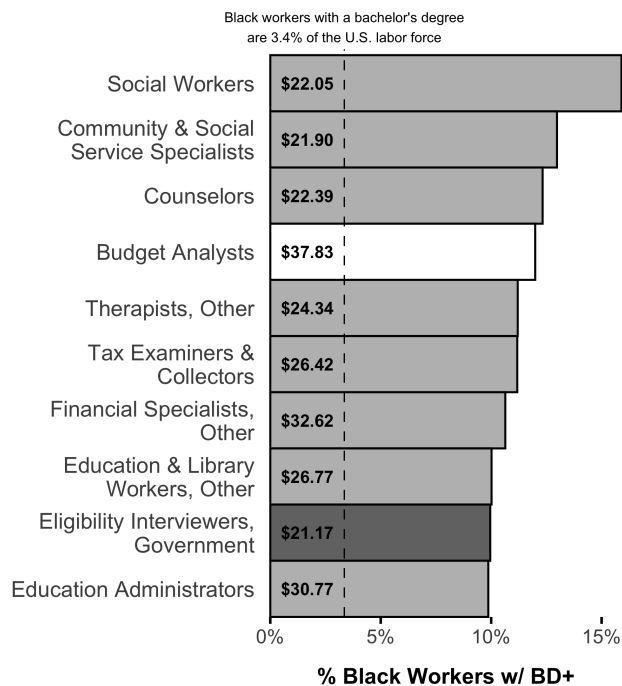
A

Black STARs are 7.6%
of the U.S. labor force

Occupation	Wage
Nursing & Home Health Aides	$13.52
Security Guards	$15.16
Postal Service Sorters & Processors	$22.69
Postal Service Clerks	$25.06
Barbers	$12.33
Licensed Practical Nurses	$20.44
Bus & Ambulance Drivers	$16.23
Parking Lot Attendants	$13.15
Industrial Truck & Tractor Operators	$16.06
Baggage Porters, Bellhops, & Concierges	$16.53

0%   10%   20%   30%

% Black STARs

B

White STARs are 32.9%
of the U.S. labor force

Occupation	Wage
Tool & Die Makers	$25.32
Millwrights	$29.21
Surveying & Mapping Technicians	$24.51
Electrical Power-Line Workers	$38.60
Machinists	$21.90
Water Treatment Plant Operators	$23.96
Parts Salespersons	$17.46
Heavy Vehicle & Mobile Equipment Technicians	$24.34
Industrial & Refractory Machinery Mechanics	$24.34
Highway Maintenance Workers	$19.47

0%   25%   50%   75%

% White STARs

C

Black workers with a bachelor's degree
are 3.4% of the U.S. labor force

Occupation	Wage
Social Workers	$22.05
Community & Social Service Specialists	$21.90
Counselors	$22.39
Budget Analysts	$37.83
Therapists, Other	$24.34
Tax Examiners & Collectors	$26.42
Financial Specialists, Other	$32.62
Education & Library Workers, Other	$26.77
Eligibility Interviewers, Government	$21.17
Education Administrators	$30.77

0%   5%   10%   15%

% Black Workers w/ BD+

D

White workers with a bachelor's degree
are 26.8% of the U.S. labor force

Occupation	Wage
Veterinarians	$43.23
Chiropractors	$32.10
Environmental Scientists & Geoscientists	$37.72
Speech Language Pathologists	$33.83
Psychologists	$37.88
Lawyers & Judges	$51.92
Secondary School Teachers	$25.96
Occupational Therapists	$35.55
Librarians	$24.59
Physical Therapists	$38.24

0%   20%   40%   60%   80%

% White Workers w/ BD+

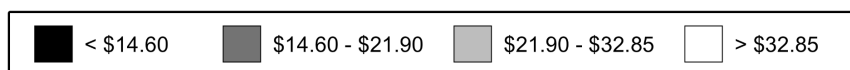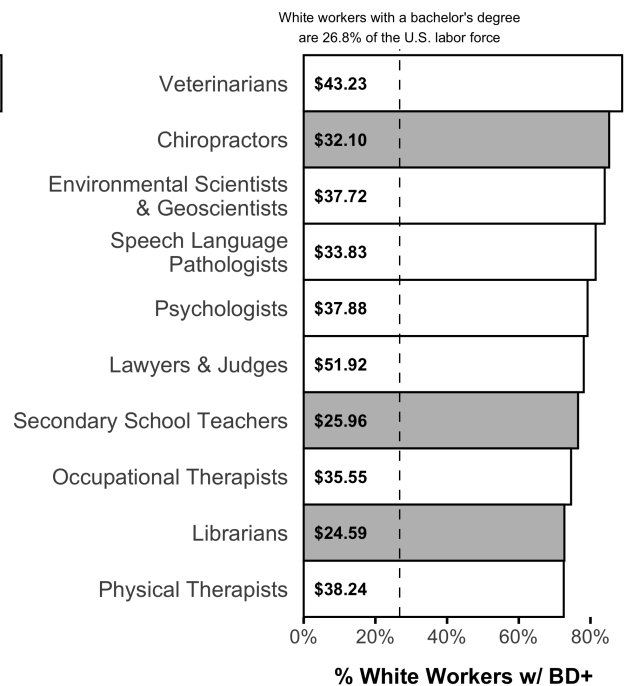Legend: ■ < $14.60   ■ $14.60 - $21.90   ■ $21.90 - $32.85   □ > $32.85

Figure 3. Top ten occupations by group representation by race and education. For each group of workers by race and degree status, we show the ten occupations with at least 50 thousand workers for

which that group makes up the largest share. Occupations are classified into wage groups using the OECD wage level thresholds such that workers in low wage occupations earn less than two-thirds of national median hourly wages (less than $14.42), workers in middle wage occupations earn between two-thirds and one-and-a-half times median hourly wages ($14.42 - $32.45), and workers in high wage occupations earn more than one-and-a-half times median hourly wages (more than $32.45). Wages are reported in 2020 dollars. Data are from the 2019 1-year American Community Survey (ACS) accessed through the University of Minnesota Integrated Public Use Microdata Series (IPUMS).

more than 80%–of the workforce. Notably, the majority of these positions are skilled, blue-collar trade jobs, all of which are lower-middle wage jobs or higher. Eight of the jobs pay higher than the national median. This pattern is consistent with prior work, which documents the historical barriers to entry that Black workers have faced for these relatively well-paying trade occupations (Bonacich 1976).

As we can see from the bottom two panels in Figure 3, Black and white workers with a bachelor's degree are also distinctly overrepresented in some occupations. Black workers with a bachelor's degree comprise a disproportionate share of those employed as social workers, community and social service specialists, counselors, budget analysts, therapists, and tax collectors. Despite their higher levels of education, the jobs in which Black workers with a bachelor's degree are overrepresented are primarily upper-middle wage. Only one out of the top ten occupations is high wage. Meanwhile, white workers with a bachelor's degree are disproportionately represented in occupations like veterinarians, chiropractors, environmental scientists and geoscientists, and speech language pathologists. Out of the top ten jobs in which white workers with a bachelor's degree make up a disproportionate share, all but three are high wage.

High levels of occupational segregation by education suggest that we should not always expect the proportion of a group of workers (e.g., Black STARs) in an occupation to align with that group's share of the labor market as a whole. For example, although Black STARs are 7.6%

of the U.S. labor force, we do not expect Black STARs to make up 7.6% of roles that typically

require a bachelor's degree or higher, such as dentists, lawyers, or chemical engineers. However,

if racial occupational segregation were primarily the result of differences in human capital and

degree attainment between Black and white workers, it is plausible to anticipate that Black and

white STARs are under- and overrepresented in the same set of occupations. The same logic

extends to workers with a bachelor's degree or higher. To investigate this hypothesis directly, we

standardize each group's share of all occupations to create a measure of relative representation.

In Figure 4, we plot the occupations with the largest absolute difference in relative

representation, separately for STARs and workers with a bachelor's degree or higher.[9] The

45-degree angle dashed line identifies occupations in which Black and white workers have

similar levels of relative representation; occupations in the bottom right of each figure are ones

in which Black workers are overrepresented relative to similarly educated white workers and

occupations in the top left of each figure are ones in which Black workers are underrepresented

relative to similarly educated White workers.

The bottom right of Figure 4A makes clear that many occupations in which Black STARs

are overrepresented do not have commensurate levels of white STARs and tend to pay low or

lower-middle wages. In comparison, occupations in which white STARs are overrepresented and

Black STARs are underrepresented (top left of the figure) are much more likely to be

upper-middle or even high-wage occupations. As Figure 4B shows, similar wage stratification

patterns emerge for workers with a bachelor's degree or higher. Black workers with a bachelor's

degree are overrepresented in relative proportions unmet by their white peers in occupations

which are typically lower-middle or upper-middle wage. In comparison, occupations in which

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[9] To aid the eye in identifying wage differences between occupations in which Black and white workers are overrepresented, we include the 50 occupations with the largest absolute difference in standardized group share in Figure 4.

white workers with a bachelor's degree are uniquely overrepresented are much more likely to be high-wage occupations.

To further unpack the relationship between an occupation's wages and the disproportionate representation of workers from each of our four groups, in Figure 5, we present the relationship between an occupation's median hourly wages and its worker composition by race and education. The vertical line marks a group's share of the entire labor market such that points to the right indicate occupations in which a group is overrepresented. To aid the eye in

A   **B**
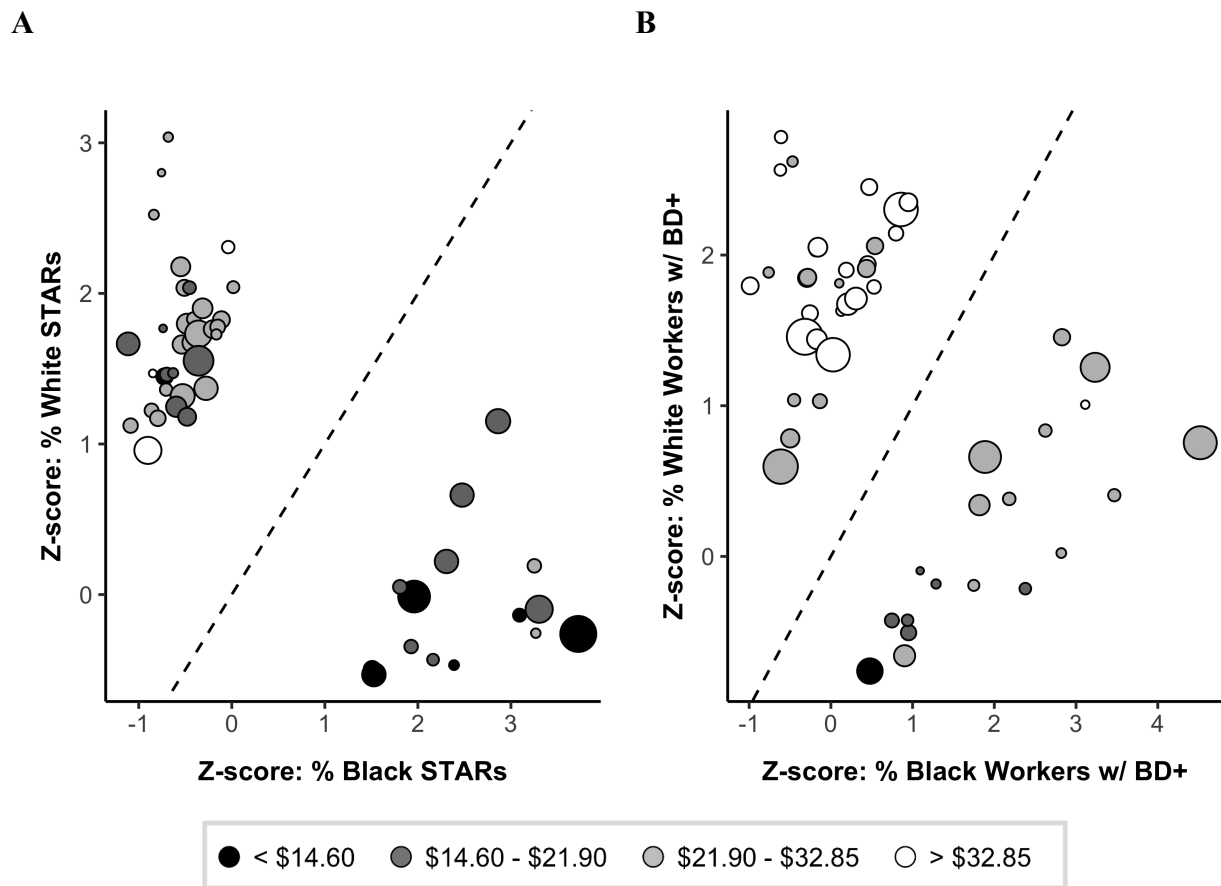
Figure 4. Top 50 occupations with largest difference in representation by race within degree status. Each point represents an occupation and is sized by the total number of workers. Occupations are limited to those with at least 50k workers. Data are from the 2019 1-year American Community Survey (ACS) accessed through the University of Minnesota Integrated Public Use Microdata Series (IPUMS).

identifying patterns in the data, we also plot the smoothed conditional means using linear regression, separately for occupations in which a group is under- or overrepresented.

Several patterns are worth noting. First, the share of Black STARs in an occupation is negatively related to that occupation's median hourly wages. This relationship flattens somewhat for occupations in which Black STARs are overrepresented, largely due to floor effects, but it is clear that Black STARs are often relegated to jobs that are poorly compensated. Although the association between group share and wages is similarly negative for occupations in which white STARs are underrepresented, the relationship takes a sharp turn among the occupations for which white STARs are overrepresented. STARs across racial groups lack access to many of the highest paying occupations, but white STARs have considerably more access than Black STARs to good-paying jobs.

Consistent with previous findings, occupations with a larger share of workers with bachelor's degrees or higher tend to be more highly compensated. Considering this pool of workers without regard to race, however, masks considerable variation. We can see in the bottom two panels of Figure 5, which compare Black and white workers with a bachelor's degree or more, that as the share of white workers with a bachelor's degree in an occupation increases, median wages consistently increase. In contrast, the relationship between group share and wages does *not* linearly increase for Black workers with a bachelor's degree. In fact, among the occupations for which Black workers with a bachelor's degree or more are most overrepresented, the relationship between group share and wages is negative, suggesting that a four-year degree does not provide Black workers access to the same set of occupations as it does for white workers.[10]

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[10] To account for the distinct patterns in Figure 5, we adopt a threshold regression model to allow the relationship between median hourly wages and a group's occupation share to vary as the group shifts from underrepresentation to
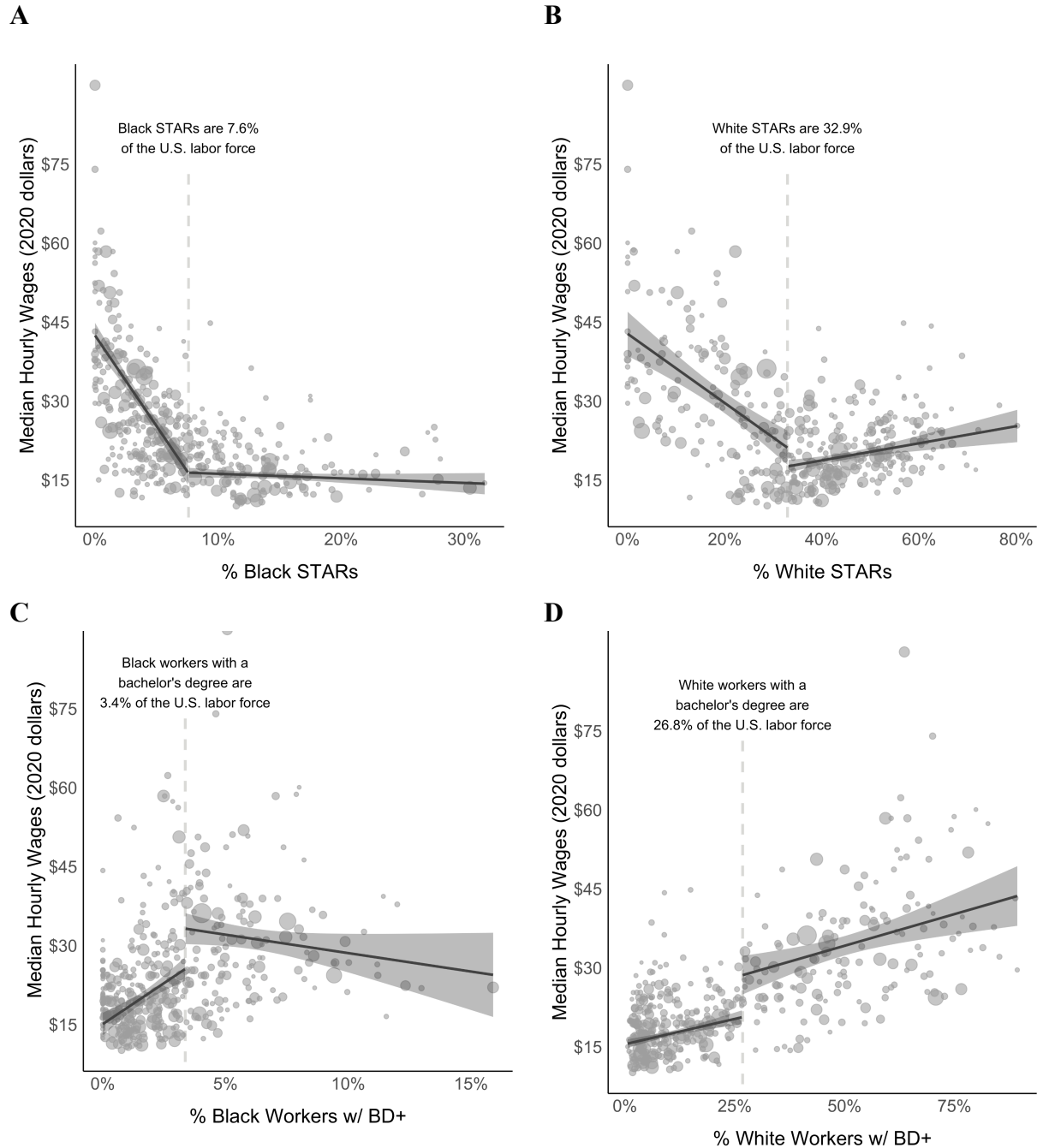
A

Black STARs are 7.6%
of the U.S. labor force

B

White STARs are 32.9%
of the U.S. labor force

C

Black workers with a
bachelor's degree are
3.4% of the U.S. labor force

D

White workers with a
bachelor's degree are
26.8% of the U.S. labor force

Figure 5. Relationship between wages and group share by race and education. Each point represents an occupation and is sized by the total number of workers in the occupation. The vertical line marks a group's share of the entire labor market such that points to the right indicate occupations in which a group is overrepresented. The two black lines represent the smoothed conditional means using weighted linear regression, calculated separately for under- and overrepresented occupations; the shaded area represents the 95% confidence area. Data are from the 2019 1-year American Community Survey (ACS) accessed through the University of Minnesota Integrated Public Use Microdata Series (IPUMS).

overrepresentation. These results support and reinforce the findings in Figure 5. See Appendix A1 for the full results.

These results demonstrate that occupational segregation has significant consequences for racial wage disparities. Black workers are distributed unequally across occupations in the U.S. labor market in a manner that reduces their earnings relative to what would be expected in a race-neutral labor market. The median hourly wage for the positions in which Black STARs are overrepresented is $15.50, compared to the $31.80 for occupations in which they are underrepresented. Unlike Black STARs, Black workers with a bachelor's degree are, on average, compensated more in the jobs in which they are overrepresented compared to where they are underrepresented. Nevertheless, they remain relegated to very different occupations than their white peers–often to positions in which they have less authority and are more likely to interface primarily with people of color.

Furthermore, independent of their degree of over or underrepresentation, Black workers with and without bachelor's degrees still make less than equally educated white workers. In 2019, the median hourly wage for Black STARs was $15.94 compared to $19.47 for white STARs. For Black workers with a bachelor's degree, the median hourly wage was $26.29, compared to $32.45 for white workers with a bachelor's degree.

Discussion and Conclusion

Our analysis demonstrates that regardless of educational attainment, considerable occupational segregation between Black and white workers persists. Even as college attendance has increased among Black Americans, the observed distribution of occupations to which Black workers have access significantly deviates from what would be expected in a race-neutral labor market. While Black workers with bachelor's degrees are situated in different, and generally more high-paying jobs than Black STARs, Black workers are concentrated in a smaller range of positions relative

to similarly educated white workers and a set of occupations that pay less than those in which their white peers are more concentrated. The results of our simulation suggest that a race-neutral labor market would yield substantially less occupational segregation for Black workers and that the reduction in occupational segregation would have the greatest impact for Black STARs.

Many of the implications of this segregation are clear. Occupational segregation in the U.S. labor market has limited the earnings and mobility of Black workers relative to what would be expected in a race-neutral labor market. Black STARs in particular are underrepresented in skilled trade occupations in which the highest concentration of STARs have historically found access to higher wages. We also find that Black workers with and without bachelor's degrees, relative to their white peers, are underrepresented in positions of authority and are concentrated in lower quality jobs with limited upward mobility. We show descriptively, for example, that Black STARs are disproportionately represented in jobs without significant leadership responsibilities even when compared to white STARs. Occupational segregation therefore likely perpetuates negative racial stereotypes about Black workers' skills, and it contributes to enduring racial wealth inequality by limiting Black workers' access to higher-paying positions (Shapiro 2004).

Not only do we learn that investment in human capital does not necessarily eliminate occupational segregation and its negative consequences, but our efforts here pointedly demonstrate the stark differences in the quality and wage compensation of jobs between Black and white STARs, both of whom compose a sizable share of today's labor force. Because we find that obtaining a bachelor's degree only modestly reduces the occupational segregation experienced by Black workers, and the majority of Black workers are STARs, efforts to reduce occupational segregation by race that focus on improving opportunities for STARs is a

potentially more promising route for reducing occupational segregation experienced by Black workers as a group. Fourteen states are moving in this direction by reducing unnecessary college degree requirements for some state jobs, recognizing that many workers are skilled through alternative routes other than college.

Our work, which explores occupational segregation at the intersection of race and education status, illuminates the path for future work that would explore additional intersections such as race-by-education-by-gender or broaden the racial category beyond the Black-white dichotomy to consider occupational segregation by education among Asian and Hispanic workers. The specific history of exclusion of Blacks within the educational system in the U.S. and in the labor market makes studying racial disparities between Black and white workers a natural place to start, but not to end.

Even among the workers that we study, one caveat with our analysis is that we focus only on racial differences between workers actually in the labor market, which misses individuals who are incarcerated. Given pervasive racial discrimination in the criminal justice system (Du 2021), a large and disproportionate percentage of Black Americans, especially Black men, are incarcerated at any point in time, removing them from the workforce (Holzer 2021; Bayer and Charles 2018).[11] Individuals who have been incarcerated are less likely to have a bachelor's degree–a relationship further exacerbated by race (Ewert, Sykes, and Pettit 2014). By one estimate, nearly 60 percent of Black male high school dropouts are imprisoned at some point in their lives (Pettit and Western 2004). Future research should therefore also consider how measures of occupational segregation by race can carefully account for the impact of racial discrepancies in incarceration on observed occupational segregation by race and education level. Thus, we acknowledge that our findings must be considered in conjunction with the

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[11] Formerly incarcerated individuals are more likely to experience unemployment as well (Couloute and Kopf 2018).

disproportionate percentage of Black workers–including the disproportionate number without

bachelor's degrees–who are missing entirely from the labor market.

Greater integration of workers is critical to improving equity in the U.S. labor market, to

unlocking the full potential and contribution of the American workforce, and to giving workers

the freedom to choose their career pathways. The emerging insight from this work suggests that

racial occupational desegregation has in fact stalled in the past two decades, and that further

study of discrimination across the intersection of race and educational attainment in the labor

market is needed to better understand the mechanisms contributing to this lack of progress.

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Data Availability

The data used in our analyses are from the following publicly available sources:

Steven Ruggles, Sarah Flood, Matthew Sobek, Danika Brockman, Grace Cooper, Stephanie Richards, and Megan Schouweiler. IPUMS USA: Version 13.0 [dataset]. Minneapolis, MN: IPUMS, 2023. https://doi.org/10.18128/D010.V13.0

Sarah Flood, Miriam King, Renae Rodgers, Steven Ruggles, J. Robert Warren and Michael Westberry. Integrated Public Use Microdata Series, Current Population Survey: Version 10.0 [dataset]. Minneapolis, MN: IPUMS, 2022. https://doi.org/10.18128/D030.V10.0

Appendix

A1. Threshold Regression Model

To account for the distinct patterns in Figure 5, we adopt a threshold regression model to allow the relationship between median hourly wages and a group's occupation share to vary as the group shifts from underrepresentation to overrepresentation. A sample-split model, which is a special case of the threshold regression model assumes the following form:

$$y_i = \beta_1 x_i + \epsilon_i, \qquad q_i \leq \gamma,$$

$$y_i = \beta_2 x_i + \epsilon_i, \qquad q_i > \gamma,$$

where q_i refers to the threshold variable and is used to split the sample into two groups. In the context of occupational segregation, y_i is an occupation's median hourly wages and x_i and q_i are a group's share of the occupation.

For each group of workers, $j = 1, ..., 4$, we estimate the following three models where the indicator, $D_j = I(X \leq \frac{n_j}{n})$ represents the threshold between occupations in which a group is under- or overrepresented. In models II and III, we include matrix Z to control for additional covariates which may impact an occupation's median hourly wage including median age, median experience, percent female, percent of workers who are government employees, and percent of workers in the South. In model III, we allow the relationship between the median hourly wages and these control variables to vary on each side of the threshold. In Table A1-1, below, we outline the three specifications that we use to estimate the relationship between an occupation's median hourly wages and a group's share of the occupation. All models are weighted by occupation size.

Model	Specification
Model I: Threshold Parameter	$Y = \alpha + \tau D + \beta_1 X + \beta_2 DX + \epsilon$
Model II: Threshold Parameter + Additional Control Variables	$Y = \alpha + \tau D + \beta_1 X + \beta_2 DX + \beta_3 Z + \epsilon$
Model III: Threshold Parameter + Additional Control Variables w/ Potential Threshold	$Y = \alpha + \tau D + \beta_1 X + \beta_2 DX + \beta_3 Z + \beta_4 DZ + \epsilon$

Table A1-1. Summary of threshold regression model specifications. The dependent variable Y is an occupation's median hourly wages, X is a a group's share of an occupation, D is an indicator function of whether a group is under- or overrepresented in an occupation, and Z controls for additional covariates which may impact an occupation's median hourly wage including median age, median experience, percent female, percent of workers who are government employees, and percent of workers in the South.

Table A1-2 presents the estimates of the regression coefficient of a group's share of an occupation in which the group is underrepresented, overrepresented, and the difference between the two. Full model results are available upon request. Regardless of model specification, there is a significant negative relationship between an occupation's median hourly wages and a group's share of the occupation for Black and white STARs for occupations in which the group is underrepresented. For occupations in which Black STARs are underrepresented, each percentage point increase of Black STARs is associated with a loss of wages of $2.44 to $3.45 per hour, depending on model specification. In comparison to an occupation with zero percent Black STARs, an occupation in which Black STARs are perfectly represented, making up 7.6% of the occupation, pays between $18.51 and $26.20 less per hour. For occupations in which white STARs are underrepresented, each percentage point increase is correlated with hourly wage losses of between $0.37 and $0.66. Occupations in which white STARs are perfectly represented

	Black STARs			White STARs			Black Workers w/ Bachelor's Degree			White Workers w/ Bachelor's Degree		
	I	II	III	I	II	III	I	II	III	I	II	III
Under Representation	-3.448*** (0.227)	-2.569*** (0.242)	-2.435*** (0.251)	-0.658*** (0.067)	-0.371*** (0.075)	-0.584*** (0.079)	3.118*** (0.695)	2.890*** (0.681)	3.116*** (0.783)	0.192** (0.074)	0.348*** (0.070)	0.228*** (0.069)
Over Representation	-0.087 (0.126)	-0.127 (0.115)	-0.082 (0.114)	0.162* (0.083)	0.021 (0.070)	0.088 (0.065)	-0.700** (0.319)	-0.488* (0.283)	-0.508* (0.317)	0.240*** (0.045)	0.251*** (0.044)	0.308*** (0.045)
Difference	3.361*** (0.260)	2.442*** (0.273)	2.352*** (0.275)	0.820*** (0.106)	0.392*** (0.102)	0.672*** (0.102)	-3.818*** (0.765)	-3.377*** (0.679)	-3.625*** (0.844)	0.048 (0.087)	-0.097 (0.076)	0.081 (0.082)
Controls	No	Yes	Yes + Threshold	No	Yes	Yes + Threshold	No	Yes	Yes + Threshold	No	Yes	Yes + Threshold
Adjusted R^2	0.549	0.631	0.648	0.349	0.552	0.628	0.249	0.533	0.530	0.528	0.656	0.710

Note:

$p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Table A1-2. Threshold regression model of occupational median hourly wages and group share. Relationship between occupational median hourly wages and a group's share of the occupation. Estimates of the regression coefficient of a group's share of an occupation in which the group is underrepresented, overrepresented, and the difference between the two are presented here. Full model results are in Appendix A3. Model I is a pure threshold model in which both the intercept and slope are allowed to vary. Model II includes additional covariates which may impact an occupation's median hourly wage including median age, median experience, percent female, percent of workers who are government employees, and percent of workers in the South. Model III allows for the relationship between median hourly wages and the control variates to vary across the threshold. All models are weighted by occupation size.

pay between $12.21 and $21.65 less per hour compared to occupations in which there are no white STARs. Across the threshold, as these groups become overrepresented, the relationship is indistinguishable from zero for both Black and white STARs, though the relationship is weakly positive for white STARs and weakly negative for Black STARs.

For both Black and white workers with a bachelor's degree or higher, there is a significant positive relationship between an occupation's median hourly wages and the group's

share of the occupation for occupations in which the group is underrepresented. For these occupations, each additional percentage point of Black workers with a bachelor's degree or more is associated with hourly wage gains of $2.89 to $3.12. In comparison to an occupation with zero percent Black workers with a bachelor's degree, an occupation in which Black STARs are perfectly represented pays between $9.83 and $10.61 more per hour. For white workers with a bachelor's degree or more, a one percentage point increase in the group's share is associated with hourly wage gains of between $0.19 and $0.35. This translates to hourly wage gains of between $5.15 and $9.33 for occupations in which white workers with a bachelor's degree are perfectly represented in comparison to occupations with no white workers with a bachelor's degree.

In comparison to Black and white STARs, the results of the threshold regression model diverge more significantly for Black and white workers with a bachelor's degree among occupations in which these workers are overrepresented. For each additional percentage point of Black workers with a bachelor's degree in an occupation beyond the national share of this group, hourly wages decrease by $0.49 to $0.70. In comparison to occupations in which Black workers with a bachelor's degree are perfectly represented, occupations with the largest share of Black workers with a bachelor's degree pay between $6.10 to $8.75 less per hour. In comparison, for white workers with a bachelor's degree or higher, increased representation continues to lead to increased wages. For each additional percentage point of white workers with a bachelor's degree or higher beyond the group's share of the national labor force, hourly wages increase by $0.24 to $0.31. This translates to hourly wage gains of between $15.00 and $19.25 when comparing occupations with the largest share of white workers with a bachelor's degree to those in which white workers with a bachelor's degree are perfectly represented.

A2. Racial Differences in Educational Attainment

By definition, STARs include workers with a high school diploma or its equivalent, workers with some college but no degree, and workers with an associate's degree. If there are significant racial differences in the educational attainment of STARs, some of the persistent racial occupational segregation between STARs may be due to unmeasured differences in human capital, particularly attainment of an associate's degree which may be viewed by employers as reliable signal of skill, ability, or potential productivity. The same confounding factor may emerge for workers with a bachelor's degree or more. If white workers are significantly more likely to have an additional degree beyond the bachelor's degree, racial differences in educational attainment may explain the occupational segregation we identify between Black and white workers with a four-year degree or more.

In order to investigate differences in educational attainment within the broader categories of STARs and workers with a bachelor's degree or more, we use the detailed educational categories in the Decennial Census and ACS. Since 1990, these detailed educational categories in the Census and ACS have been based on degree attainment, however, in 1980, the categories instead denote the number of years of college, which make direct comparison less precise. For example, it is a relatively safe assumption that the vast majority of workers with four or more years of college have a bachelor's degree or higher, but it is less clear whether a worker with five years of college completed a degree beyond the bachelor's degree. Similarly, we can assume that workers with one year or less of college are unlikely to have completed a degree, but workers with two to three years of college may have completed an associate's degree or they may have run into barriers before completing a bachelor's degree program. As a result, we exclude 1980

from the main tables to follow and present a separate analysis of 1980 by number of years of education in Table A2-3.

We test the hypothesis that there are racial differences in educational attainment within the broader categories of STARs and workers with a four-year degree or higher in two ways. First, in Table A2-1, we present the share of STARs with a high school diploma or its equivalent, with some college but no degree, and with an associate's degree for Black and white workers over time. Similarly, we present the share of workers with a bachelor's degree or more who have a bachelor's degree alone, a master's degree, a professional degree, and a doctorate degree. Second, in Table A2-2, we measure the dissimilarity index between Black and white workers using more detailed educational categories than appear in the main paper.

In general, Black and white STARs have similar levels of educational attainment. As can be seen in Table A2-1, about 45 percent of STARs have a high school diploma or its equivalent, about 40 percent have some college, but no degree, and the remaining 15 percent have an associate's degree. There are minor differences between Black and White STARs, with the largest differences emerging in 2019 among workers with an associate's degree. As of 2019, 19.1% of white STARs have an associate's degree in comparison to 15.7% of Black STARs.

Over 60 percent of workers with a bachelor's degree or higher have a bachelor's degree alone and about a quarter of workers with a bachelor's degree or higher have a master's degree. This is consistent for both Black and white workers. Some of the largest racial differences occur in the share of workers with a professional degree, such as a law degree or medical degree. In 2019, over 48 percent of workers with a professional degree were in two occupations: lawyers, judges, magistrates, and other judicial workers and physicians and surgeons.

		1990		2000		2010		2019	
		Black	White	Black	White	Black	White	Black	White
STARs	High school diploma, or equivalent	50.8%	51.1%	46.7%	46.5%	44.8%	44.6%	45.0%	42.9%
	Some college, no degree	37.8%	36.0%	41.9%	39.8%	41.9%	39.0%	39.3%	38.0%
	Associate's degree	11.4%	12.9%	11.5%	13.7%	13.3%	16.4%	15.7%	19.1%
Bachelor's degree or more	Bachelor's degree	66.3%	63.5%	67.0%	63.2%	65.4%	62.6%	61.2%	61.8%
	Master's degree	25.5%	23.7%	24.3%	24.6%	26.6%	26.0%	30.6%	26.9%
	Professional degree	5.6%	8.8%	5.8%	8.2%	4.6%	7.2%	4.7%	6.9%
	Doctoral Degree	2.7%	3.9%	2.9%	3.9%	3.3%	4.2%	3.5%	4.4%

Table A2-1. Detailed educational attainment by race. The population of interest is workers who are aged 25 or older and active in the labor force. Workers skilled through alternative routes (STARs) have a high school diploma or equivalent and have developed their skills through routes other than a four-year diploma such as community college, apprenticeships, bootcamps, and, most commonly, on-the-job work experience. Data are from the 1990 and 2000 U.S. Decennial Censuses and the 2010 and 2019 1-year American Community Surveys (ACS) accessed through the University of Minnesota Integrated Public Use Microdata Series (IPUMS).

While racial differences in professional degree attainment certainly explain racial differences in access to these occupations, it is unlikely that observed occupational segregation between Black and white workers with a bachelor's degree across all 422 occupations in our analysis is driven by these occupations. For example, in 2019, the dissimilarity index between

Black and white workers with a bachelor's degree was 0.221. If we exclude these two occupations, the dissimilarity index would be 0.220.

Despite minor racial differences in the educational attainment within the categories of STARs and workers with a bachelor's degree or higher, Table A2-2 confirms that the occupational segregation by race and education that we identify is not the result of our choice of educational categories. If we measure the dissimilarity index between Black and white workers with highly detailed education categories, we find consistent levels of occupational segregation within educational subcategories. That is, occupational segregation between Black and white STARs is not the result of differences in educational attainment between Black and white STARs. Similarly, occupational segregation between Black and white workers with a bachelor's degree or higher is not the result of differences in educational attainment beyond the bachelor's degree.

		Dissimilarity Index (D)			
		1990	*2000*	*2010*	*2019*
STARs	High school diploma, or equivalent	0.284	0.266	0.275	0.296
	Some college, no degree	0.272	0.251	0.259	0.281
	Associate's degree	0.238	0.227	0.234	0.268
Bachelor's degree or more	Bachelor's degree	0.235	0.219	0.225	0.234
	Master's degree	0.236	0.204	0.198	0.217
	Professional degree	0.203	0.192	0.207	0.246
	Doctoral Degree	0.246	0.254	0.229	0.284

Table A2-2. Occupational segregation over time by race and degree status. The index of dissimilarity measures how evenly workers are distributed within the 422 occupations in the 2010 harmonized occupations codes created by University of Minnesota Integrated Public Use Microdata Series (IPUMS). The population of interest is workers who are aged 25 or older and active in the labor force. Workers skilled through alternative routes (STARs) have a high school diploma or equivalent and have developed their skills through routes other than a four-year diploma such as community college, apprenticeships, bootcamps, and, most commonly, on-the-job work experience. Data are from the 1990 and 2000 U.S. Decennial Censuses and the 2010 and 2019 1-year American Community Surveys (ACS) accessed through IPUMS.

		Dissimilarity Index (D)
		1980
STARs	High school diploma, or equivalent	0.315
	One year or less, college	0.314
	Two years, college	0.312
	Three years, college	0.313
Bachelor's degree or more	Four years, college	0.298
	Five years, college	0.239
	Six years, college	0.252
	Seven years, college	0.301
	Eight years, college	0.310

Table A2-3. Occupational segregation over time by race and years of college, 1980. The index of dissimilarity measures how evenly workers are distributed within the 351 occupations in the 2010 harmonized occupations codes created by University of Minnesota Integrated Public Use Microdata Series (IPUMS). The population of interest is workers who are aged 25 or older and active in the labor force. Workers skilled through alternative routes (STARs) have a high school diploma or equivalent and have developed their skills through routes other than a four-year diploma such as community college, apprenticeships, bootcamps, and, most commonly, on-the-job work experience. Data are from the 1980 2000 U.S. Decennial Censuses accessed through IPUMS.