Macroeconomics of Racial Disparities: Discrimination, Labor Market, and Wealth

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Abstract

This paper examines the impact of racial discrimination in hiring on employment, wage, and wealth disparities between black and white workers. Using a labor search-and-matching model with racially prejudiced and non-prejudiced firms, we show that labor market frictions sustain discriminatory practices as an equilibrium outcome. These practices account for 44% to 52% of the average wage gap and 16% of the median wealth gap. Discriminatory hiring also amplifies unemployment and wage volatility for black workers, increasing their labor market risks over business cycles. Eliminating prejudiced firms reduces these disparities and improves black workers' welfare, though it slightly decreases overall economic welfare.

JEL classification: D14, E21, J15, J64, J65

Keywords: search-and-matching, heterogeneous agents, racial inequality, unemployment, wealth distribution, business cycles

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1 Introduction

Discrimination is often considered inefficient or a response to information asymmetry.[1] Market competition and better information are expected to eliminate discrimination over time. However, substantial empirical evidence shows that discriminatory practices persist across markets, perpetuating significant racial disparities.[2] Only recently has macroeconomic research begun to explore racial disparities.[3] Yet, the role of discriminatory practices in shaping these disparities remains under-explored. Developing a general equilibrium framework to explain the persistence of discrimination and its consequences is crucial for understanding the macroeconomic impacts of racial disparities and informing effective policymaking.

This paper constructs a labor search-and-matching framework to capture the persistence of hiring discrimination based on race. We show that hiring discrimination accounts for 44% to 52% of the black-to-white average wage gap and 16% of the racial median wealth gap. Additionally, hiring discrimination intensifies unemployment and wage volatility for black workers, creating a countercyclical racial unemployment gap and diverging racial wage cyclical patterns. The model incorporates two types of firms: prejudiced firms, which hire only white workers, and non-prejudiced firms, which hire all workers equally. We include additional racial differences in the model as differences in bargaining power and the likelihood of experiencing wealth destruction. While all workers compete for jobs, white workers have additional opportunities with prejudiced firms. Matched worker-firm pairs negotiate wages to maximize their joint surplus. Upon calibration, the model endogenously produces lower

[1] See Becker (1957) and Lang and Spitzer (2020) for discussions on taste-based and statistical discrimination theories.

[2] For example, Couch and Fairlie (2010); Biddle and Hamermesh (2013); Kuhn, Schularick, and Steins (2020); Derenoncourt and Montialoux (2021); Lippens, Vermeiren, and Baert (2023). Resume studies consistently reveal racial discrimination even when controlling for candidate qualifications (e.g., Bertrand and Mullainathan, 2004; Bertrand and Duflo, 2017; Kline, Rose, and Walters, 2022). Gaps in labor income and wealth between black and white households have persisted long after the Civil Rights Movement (e.g., Cajner, Radler, Ratner, and Vidangos, 2017; Derenoncourt, Kim, Kuhn, and Schularick, 2023). Small and Pager (2020) argues that discrimination reinforces itself across domains and constitutes a form of market failure.

[3] See, for example, Nakajima (2021), Aliprantis, Carroll, and Young (2023), Boerma and Karabarbounis (2021), Ganong, Jones, Noel, Greig, Farrell, and Wheat (2020), Lee, Macaluso, and Schwartzman (2021).

job-finding rates, higher unemployment rates, and lower bargained wages for black workers. Even without further financial frictions, the model generates significant racial disparities in wealth accumulation.

The main message of this paper is that labor market friction can sustain hiring discrimination as an equilibrium outcome. Our calibration shows that prejudiced firms incur higher vacancy posting costs to discriminate against black workers. As we gradually increase these costs, prejudiced firms slowly reduce their vacancy postings and employment, while their profits adjust to satisfy the free-entry condition. Ultimately, we more than double the benchmark calibrated posting cost until the entire expected value of entering as a discriminatory firm is eliminated. This indicates that prejudiced firms maintain sufficient profit to absorb higher vacancy posting costs, even under competitive market conditions.

Moreover, hiring discrimination perpetuates the equilibrium economy through firms' vacancy postings. Prejudiced firms compete with non-prejudiced firms for unemployed white workers, driving up wage rates for white workers across the economy. This wage pressure reduces the expected profits of non-prejudiced firms, leading them to post fewer vacancies overall. The resulting decline in non-prejudiced job openings directly limits employment opportunities for black workers, contributing to lower wages, higher unemployment rates, and adverse wealth accumulation for them.

In a counterfactual economy without prejudiced firms, the racial unemployment gap disappears, and the wage gap decreases significantly. Such reduction in labor market disparity leads to asymmetric welfare change. Black workers' employment opportunities and wages increase because non-prejudiced firms expand their vacancy postings to fill positions left by prejudiced firms. As a result, black workers experience a welfare increase, with the most significant gain among the high-productivity black workers. White workers, however, lose the exclusive job opportunities that prejudiced firms previously provided. Their average wage declines, and their unemployment rate rises. This leads to a moderate welfare decrease, especially among the lowest-productivity and lowest-wealth white workers. Due to asymmetrical job destruction shocks and vacancy posting costs, non-prejudiced firms cannot fully replace prejudiced firms. However, if we maintain the race-specific job destruction shocks, eliminating prejudiced hiring has a much smaller adverse impact on white workers.

We further introduce aggregate shocks to the economy and show that hiring discrimination generates distinct business cycle dynamics for black and white workers. Our model successfully replicates the observed countercyclical and volatile racial unemployment rate gap, as well as the more procyclical and volatile average wage rate for black workers. Upon removing prejudiced firms, the business cycle patterns of the racial unemployment rate gap disappear. The volatility and cyclicality of average wages for black and white workers become much more similar. This provides theoretical evidence to Cajner et al. (2017) that firm-side discrimination contributes to the business cycle differences between black and white workers, and non-market demographic factors alone do not fully account.

Lastly, we examine the associated business cycle welfare change between black and white workers when discriminatory hiring contributes to more volatile labor market outcomes for black workers. Not all workers benefit from a less volatile economy without discriminatory firms. Black workers gain an average of 0.02% in welfare, whereas white workers face a welfare loss of 0.01%. Different from the steady-state welfare values, among black workers, those with high productivity and high wealth gain the most. Among white workers, those with high productivity and high wealth lose the most, experiencing the largest welfare decreases within their group.

This paper contributes to the ongoing discussion on the persistence of racial inequality by focusing on the disparate labor market conditions of white and black workers. Numerous studies have documented racial discrimination in pay and employment opportunities that persist despite policy interventions (e.g., Coate and Loury, 1993; Black, 1995; Rosén, 1997; Bertrand and Mullainathan, 2004; Manduca, 2018). Recent empirical research stresses that racial wage and employment gaps persist across education levels, skill sets, and cohorts. These disparities are not solely attributable to differences in individual qualifications (e.g., Pena, 2018; Cheng, Tamborini, Kim, and Sakamoto, 2019). Building on this insight, our paper develops a model in which discriminatory hiring practices endogenously perpetuate labor market inequalities. Our work adds to the literature by providing a theoretical framework that explains how hiring discrimination can be sustained as an equilibrium outcome in the labor market.

While much of the literature focuses on static disparities, fewer studies document how macroeconomic fluctuations impact black and white workers differently. Notably, Couch and Fairlie (2010) demonstrate that black workers are disproportionately affected during recessions, being the last hired in upturns and the first fired in downturns. Biddle and Hamermesh (2013) find that the discriminatory wage gap is procyclical, widening during economic expansions. Similarly, Cajner et al. (2017) show that black workers experience higher unemployment rate volatility and are more likely to be involuntarily employed part-time. Daly, Hobijn, and Pedtke (2020) suggest that limited employment opportunities for black workers contribute to the growing racial earnings gap. Our paper adds to this body of work by evaluating the impact of hiring discrimination on the cyclical aspects of racial disparities, examining how discriminatory practices exacerbate volatility and cyclicality in employment and wages for black workers.

An emerging strand of literature explores racial disparities in wealth accumulation. Studies such as Derenoncourt et al. (2023), Derenoncourt, Kim, Kuhn, and Schularick (2022), Kuhn et al. (2020), Barsky, Bound, Charles, and Lupton (2002), and McIntosh, Moss, Nunn, and Shambaugh (2020) document significant wealth gaps between black and white households. For example, Derenoncourt et al. (2023) provide a historical account of wealth segregation over the past 150 years, showing persistent and substantial disparities. Boerma and Karabarbounis (2021) and Aliprantis et al. (2023) analyze the impact of historical discrimination on earnings, bequests, and capital returns within steady-state models that do not consider aggregate risks. Furthermore, Ganong et al. (2020) demonstrate that income risks affect individuals differently across racial groups due to wealth differences. Building on these findings, Bartscher, Kuhn, Schularick, and Wachtel (2021) and Lee et al. (2021) discuss how monetary policy can have disparate effects on workers of different racial backgrounds. Our paper contributes to this literature by showing that employer discrimination not only affects immediate labor market outcomes but also spills over into long-term wealth accumulation disparities between black and white workers.

Germane to our project, Nakajima (2021) develop a search-and-matching model to examine how monetary policies exacerbate racial differences in the labor market. Our model explicitly distinguishes between discriminatory and non-discriminatory firms in the hiring process and directly examines how hiring discrimination impacts black workers and the broader economy. We analyze the spillover effects of discriminatory hiring practices on both labor and wealth disparities, offering a comprehensive theoretical understanding of these dynamics over the long run and across business cycles.

In a broader context, our paper joins the growing discussion on the distributional impact of economic growth and macroeconomic policies by focusing on the heterogeneous outcomes for black and white workers. This aligns with studies like Caballero and Hammour (1994), Jaimovich and Siu (2020), and Heathcote, Perri, and Violante (2020), which provide evidence that recessions disproportionately hurt disadvantaged individuals. Borella, De Nardi, and Yang (2018) show that incorporating gender differences in a life-cycle model improves its empirical fit, emphasizing the importance of accounting for demographic heterogeneity. Krusell and Smith (1998) conclude that heterogeneity in wealth does not alter business cycle fluctuations. Yet, Yum, Jang, and Sunakawa (2023) show that heterogeneity could generate large aggregate fluctuations when introducing non-convexity in budget constraint through progressive tax. Our paper demonstrates that incorporating racial differences into labor market models enhances their ability to capture business cycle fluctuations. It also provides insights into how racial wedges in labor search processes transmit individual risks and heterogeneity into aggregate economic dynamics.

The rest of the paper proceeds as follows. Section 2 lays out theoretical framework.

Section 3 discusses the calibration strategy. Section 4 examines the steady-state implications of racial discrimination. Section 5 provides business cycle implications. Section 6 concludes the paper.

2 Model

This section presents a model of labor market discrimination without aggregate uncertainty. We use this framework to understand the role of hiring discrimination in driving the racial gaps in labor market outcomes and wealth.

2.1 Environment

The model has a unit measure of workers, who are either black or white, $R \in \{bl, wh\}$. Two types of firms post vacancies to hire unemployed workers, subject to search and matching frictions. Prejudiced firms (p) actively discriminate against black workers and hire only white workers. Non-prejudiced firms (np) hire both black and white workers without discrimination. Prejudiced and non-prejudiced firms also have type-specific job destruction shocks. To ease exposition, we drop the time subscripts and use a prime symbol (') to denote the variables in the next period.

Workers are either employed (with p or np firm) or unemployed. Those who become unemployed in the current period receive unemployment benefits and continue to receive them in the future with probability P_e. The workers face idiosyncratic productivity shocks s, following an AR(1) process $\log(s') = \rho_s \log(s) + \epsilon_s$, with $\epsilon_s \overset{iid}{\sim} N(0, \sigma_s^2)$. Workers also differ in their asset holdings. They can save using these risk-free assets to partially insure themselves against the labor market risks. Following Mukoyama (2013), workers also receive race-specific extreme wealth shocks with probability $\epsilon_R \in \{\epsilon_{bl}, \epsilon_{wh}\}$. Upon realization of the shock, the worker loses all their wealth. Altogether, workers are heterogeneous across race (R), labor market status (e), idiosyncratic productivity (s), and wealth (a). The endogenous distribution of workers is summarized by $\mu(e, R, s, a)$. All endogenous aggregate variables depend on μ. Individual workers may move around the distribution between periods; however, the overall distribution remains stationary. We omit the record of μ in the steady state and will reintroduce μ when augmenting the model with aggregate shocks in Section 5.

2.2 Labor market search and matching

The total number of unemployed workers, denoted as u, is the sum of unemployed black workers (u_{bl}) and unemployed white workers (u_{wh}). There are v_{np} vacancies available in the non-prejudiced market, while the number of vacancies in the prejudiced market is v_p. Non-prejudiced firms search among both black and white unemployed workers, resulting in a non-prejudiced market tightness defined as $\theta_{np} = \frac{v_{np}}{u}$. In contrast, prejudiced firms only hire unemployed white workers, which gives the prejudiced market tightness $\theta_p = \frac{v_p}{u_{wh}}$. Following the works of Den Haan, Ramey, and Watson (2000) and Petrosky-Nadeau, Zhang, and Kuehn (2018), unemployed workers and vacant firms match through a constant returns to scale matching function

$$M(u, v) = \frac{uv}{(u^\iota + v^\iota)^{1/\iota}}, \tag{1}$$

with $\iota > 0$. As documented by Den Haan et al. (2000), this functional form ensures that the matching probabilities lie within 0 and 1. The probability for an unemployed worker to match with a vacant np firm is $f(\theta_{np}) = M(u, v_{np})/u = (1 + \theta_{np}^{-\iota})^{-1/\iota}$, while the probability that a white unemployed worker matches with a vacant p firm is $f(\theta_p) = M(u_{wh}, v_p)/u_{wh} = (1 + \theta_p^{-\iota})^{-1/\iota}$. Correspondingly, the probability of filling a vacant np firm is $q(\theta_{np}) = M(u, v_{np})/v_{np} = (1 + \theta_{np}^{\iota})^{-1/\iota}$, while the probability of filling a vacant p firm is $q(\theta_p) = M(u_{wh}, v_p)/v_p = (1 + \theta_p^{\iota})^{-1/\iota}$. In addition, non-prejudiced matches get separated with probability λ_{np}, while the prejudiced matches separate at the rate λ_p.

2.3 Unemployment Insurance

Unemployment insurance is characterized by the replacement rate h, eligibility probability P_e, and maximum coverage level χ. Following Setty and Yedid-Levi (2021), eligible workers receive unemployment benefits $b(R, s, a) = min\{h\bar{w}(R, s, a), \chi\}$, where $\bar{w}(R, s, a)$ is the counterfactual wage earned by an employed worker with race R, productivity s, and wealth a. We adopt the counterfactual wage to ease the computation burden of tracking wage history. Similar to Mitman and Rabinovich (2015), newly unemployed workers receive unemployment benefits with certainty and continue to receive benefits next period with probability P_e. If an unemployed worker loses their eligibility to receive benefits, they continue to remain ineligible in the future. Unemployment benefits are funded through a proportional tax τ on the labor income, and the government sets τ to balance its budget.[4]

2.4 Workers

The value function of an employed individual with race R, productivity s, asset a, and working with a np firm is given by $W_{np}(R, s, a)$, while that of a white worker employed with a p firm is given by $W_p(wh, s, a)$. Since the unemployment benefit is indexed to the worker's counterfactual wage, the values of the unemployed workers eligible for benefits depend on whether they worked with a non-prejudiced ($U^I_{np}(R, s, a)$) or a prejudiced ($U^I_p(wh, s, a)$) firm previously. An unemployed worker who is not eligible for unemployment benefits has $U^N(R, s, a)$ over their lifetime. All the workers discount their future utility by β. Similar to Nakajima (2012) and Setty and Yedid-Levi (2021), we assume that workers cannot borrow. This imposes an exogenous constraint of $a' \geq 0$ on all workers.

[4] We intentionally model a more realistic and complex unemployment insurance structure to capture the racial disparities in the incidence and take-up of unemployment insurance. This helps us generate racial differences in income and wealth distribution, given the asymmetric labor market and wealth risks.

2.4.1 Employed with *np* firm

Equation (2) describes an employed worker of race R with productivity s and asset holdings a, working in a np firm. The worker chooses consumption c and future savings a' to maximize their discounted lifetime utility. Their income constitutes of period wage ω_{np} net of payroll tax τ, current savings $(1+r)a$, and dividends d. The expectation of the worker's future value is taken over the idiosyncratic productivity shock s and the race-specific probability of extreme wealth shock ϵ_R.

$$
\begin{aligned}
W_{np}(R,s,a) &= \max_{c,a'\geq 0} \left\{ u(c) + \beta \sum_{s'} \pi_{ss'}[(1-\epsilon_R)\hat{W}_{np}(R,s',a') + \epsilon_R \hat{W}_{np}(R,s',0)] \right\} \\
&\text{s.t.} \\
c + a' &= (1-\tau)\omega_{np}(R,s,a) + (1+r)a + d
\end{aligned}
\tag{2}
$$

The future value of an employed worker for each s' and after realizing ϵ_R can expand to Equation (3). If the worker receives a job destruction shock, specific to np firms, one becomes unemployed with probability λ_{np}. Otherwise, one may stay employed with probability $1-\lambda_{np}$. If unemployed, the worker can receive unemployment benefits and realize a value of U^I_{np}.

$$
\hat{W}_{np}(R,s',a') = \lambda_{np} U^I_{np}(R,s',a') + (1-\lambda_{np}) W_{np}(R,s',a') \tag{3}
$$

2.4.2 Employed with *p* firm

Equation (4) describes the case of a worker employed by a p firm. It is analogous to the previous case, and we only keep track of white workers since prejudiced firms do not hire black workers.

$$W_p(wh,s,a) = \max_{c,a'\geq 0} \Big\{ u(c) + \beta \sum_{s'} \pi_{ss'} [(1-\epsilon_{wh}) \hat{W}_p(wh,s',a') + \epsilon_{wh} \hat{W}_p(wh,s',0)] \Big\}$$

$$\text{s.t.} \tag{4}$$

$$c + a' = (1-\tau)\omega_p(wh,s,a) + (1+r)a + d$$

The matched worker receives a job destruction shock specific to p firms, with probability λ_p. A worker losing the job in the current period is eligible for unemployment benefits and earns value U_p^I in the next period. For each s' and after realizing ϵ_{wh}, an employed worker's future value expands to Equation (5).

$$\hat{W}_p(wh,s',a') = \lambda_p U_p^I(wh,s',a') + (1-\lambda_p) W_p(wh,s',a') \tag{5}$$

2.4.3 Unemployed and eligible workers

Since unemployment insurance is proportional to the counterfactual wage, the value obtained by an unemployed and eligible worker depends on whether the past employment was in a p or a np firm. In addition, unemployed white workers can receive job offers from both p and np firms, while black workers can get matched only with np firms.

Unemployed black worker from *np* firm

Equation (6) describes the value of an unemployed black worker eligible for benefits. The worker encounters the extreme wealth shock with probability ϵ_{bl}. The worker receives unemployment insurance payout, $b_{np}(bl,s,a)$, net of labor income tax rate τ, previous savings, and lump-sum dividend transfer d.

$$
\begin{aligned}
U^I_{np}(bl,s,a) = \max_{c,a'\geq 0} & \left\{u(c) + \beta \sum_{s'} \pi_{ss'}[(1-\epsilon_{bl})\hat{U^I}_{np}(bl,s',a') + \epsilon_{bl}\hat{U^I}_{np}(bl,s',0)]\right\} \\
\text{s.t.} & \\
c + a' = (1-\tau)b_{np}(bl,s,a) + (1+r)a + d &
\end{aligned}
\tag{6}
$$

Their future value $\hat{U^I}_{np}(bl,s',a')$ expands according to Equation (7):

$$
\hat{U^I}_{np}(bl,s',a') = f(\theta_{np})W_{np}(bl,s',a') + (1-f(\theta_{np}))[P_e U^I_{np}(bl,s',a') + (1-P_e)U^N(bl,s',a')] \tag{7}
$$

The unemployed worker finds a job with probability $f(\theta_{np})$, which moves them to a future value of $W_{np}(bl,s',a')$. Otherwise, they either continue to receive unemployment benefits with probability P_e or lose their benefit with probability $(1-P_e)$. If one loses the benefit, their value function becomes $U^N(bl,s',a')$.

Unemployed white worker from *np* firm

Unemployed white workers are recruited by both p and np firms. Equation (8) describes their value function. Like a black worker, a white worker encounters an extreme wealth shock with probability ϵ_{wh}. They also have a budget constraint from post-tax unemployment insurance payout, previous savings, and a lump-sum dividend transfer.

$$
\begin{aligned}
U^I_{np}(wh,s,a) = \max_{c,a'\geq 0} & \left\{u(c) + \beta \sum_{s'} \pi_{ss'}[(1-\epsilon_{wh})\hat{U^I}_{np}(wh,s',a') + \epsilon_{wh}\hat{U^I}_{np}(wh,s',0)]\right\} \\
\text{s.t.} & \\
c + a' = (1-\tau)b_{np}(wh,s,a) + (1+r)a + d. &
\end{aligned}
\tag{8}
$$

Equation (9) describes the future value of an unemployed white worker with idiosyncratic productivity s' and asset a'. With probability $(1-f(\theta_{np}))f(\theta_p)$, the worker receives an only job offer from a p firm. With probability $f(\theta_{np})(1-f(\theta_p))$, they receive an only offer from a np firm. With probability $f(\theta_{np})f(\theta_p)$, they receive offers from both np and p firms simultaneously. If the worker receives both p and np offers, they will choose the job with a higher lifetime value. The white worker will remain unemployed if they don't receive any offers (with probability $(1-f(\theta_p))(1-f(\theta_{np}))$). In this case, one may continue to receive unemployment benefits with probability P_e. Otherwise, one moves to a state of receiving no unemployment benefit with probability $(1-P_e)$.

$$
\begin{aligned}
\hat{U^I}_{np}(wh, s', a') = {} & (1-f(\theta_{np}))f(\theta_p)W_p(wh, s', a') + f(\theta_{np})(1-f(\theta_p))W_{np}(wh, s', a') \\
& + f(\theta_{np})f(\theta_p)\max\{W_p(wh, s', a'), W_{np}(wh, s', a')\} \\
& + (1-f(\theta_p))(1-f(\theta_{np}))\Big[P_e U^I_{np}(wh, s', a') + (1-P_e)U^N(wh, s', a')\Big]
\end{aligned} \tag{9}
$$

Unemployed white worker from p firm

Equation (10) describes the problem faced by a white worker who last worked with a p firm. The problem is identical to the previous case, except that they receive a payout of $b_p(wh, s, a)$ from the unemployment insurance.

$$
\begin{aligned}
U^I_p(wh, s, a) = {} & \max_{c, a' \geq 0} \Big\{u(c) + \beta \sum_{s'} \pi_{ss'}[(1-\epsilon_{wh})\hat{U^I}_p(wh, s', a') + \epsilon_{wh}\hat{U^I}_p(wh, s', 0)]\Big\} \\
& \text{s.t.} \\
& c + a' = (1-\tau)b_p(wh, s, a) + (1+r)a + d
\end{aligned} \tag{10}
$$

After realizing ϵ_{wh} and for each s', the unemployed worker's future value is described in Equation (11). It is analogous to Equation (9).

$$
\begin{aligned}
\hat{U^I}_p(wh,s',a') &= (1-f(\theta_{np}))f(\theta_p)W_p(wh,s',a') + f(\theta_{np})(1-f(\theta_p))W_{np}(wh,s',a') \\
&+ f(\theta_{np})f(\theta_p)\max\{W_p(wh,s',a'),W_{np}(wh,s',a')\} \\
&+ (1-f(\theta_p))(1-f(\theta_{np}))\Big[P_eU_p^I(wh,s',a') + (1-P_e)U^N(wh,s',a')\Big]
\end{aligned} \tag{11}
$$

2.4.4 Unemployed and ineligible workers

Ineligible workers have lost their unemployment insurance and are still searching for jobs. They no longer receive unemployment benefits unless they successfully find a job and transition out of employment again. Therefore, their consumption relies solely on previous savings and lump-sum dividends, independent of their prior employment status.

Black worker

Equation (12) describes the problem of an unemployed black worker searching for jobs without unemployment insurance.

$$
\begin{aligned}
U^N(bl,s,a) &= \max_{c,a'\geq 0}\Big\{u(c) + \beta\sum_{s'}\pi_{ss'}\Big[(1-\epsilon_{bl})\hat{U^N}(bl,s',a') + \epsilon_{bl}\hat{U^N}(bl,s',0)\Big]\Big\} \\
&\text{s.t.} \\
c + a' &= (1+r)a + d
\end{aligned} \tag{12}
$$

And Equation (13) expands the future value of the black worker. One has a probability of $f(\theta_{np})$ of finding a job - only with a np firm; otherwise, they remain unemployed and ineligible.

$$
\hat{U^N}(bl,s',a') = f(\theta_{np})W_{np}(bl,s',a') + (1-f(\theta_{np}))U^N(bl,s',a') \tag{13}
$$

White worker

Equation (14) describes the problem of a white worker searching for jobs without unemployment insurance.

$$
\begin{aligned}
U^N(wh, s, a) = &\max_{c, a' \geq 0} \Big\{ u(c) + \beta \sum_{s'} \pi_{ss'} \Big[(1-\epsilon_{wh}) \hat{U^N}(wh, s', a') + \epsilon_{wh} \hat{U^N}(wh, s', 0) \Big] \Big\} \\
&\text{s.t.} \\
c + a' &= (1+r)a + d
\end{aligned} \tag{14}
$$

And Equation (15) expands the future value of the white worker in this scenario. It is nearly identical to Equation (11). With a probability $(1-f(\theta_p))(1-f(\theta_{np}))$, the unemployed worker does not find any job and remains unemployed and ineligible.

$$
\begin{aligned}
\hat{U^N}(wh, s', a') = &(1-f(\theta_{np}))f(\theta_p)W_p(wh, s', a') + f(\theta_{np})(1-f(\theta_p))W_{np}(wh, s', a') \\
&+ f(\theta_p)f(\theta_{np}) \max\{W_p(wh, s', a'), W_{np}(wh, s', a')\} \\
&+ (1-f(\theta_p))(1-f(\theta_{np}))U^N(wh, s', a')
\end{aligned} \tag{15}
$$

2.5 Firms

A large number of p and np firms post vacancies after paying the vacancy posting costs. These firms are risk-neutral and discount their future profits using the equilibrium real interest rate.

2.5.1 Vacant *np* firm

Vacant np firms pay a cost of κ_{np} and search among all unemployed workers irrespective of their race. These firms match with an unemployed worker with probability $q(\theta_{np})$. Equation (16) describes the value of a vacant np firm, V_{np}.

$$V_{np} = -\kappa_{np} + \Big(\frac{q(\theta_{np})}{1+r}\Big) \int_a \Big\{ \sum_{s'} \pi_{ss'} \Big[J_{np}(bl, s', a') \frac{\phi_u(bl, s, a)}{u} \Big]$$
$$+ \sum_{s'} \pi_{ss'} \Big[\mathbb{1}_{\{W_{np}(wh,s',a') \geq W_p(wh,s',a')\}} \Big(J_{np}(wh, s', a') \frac{\phi_u(wh, s, a)}{u} \Big) \tag{16}$$
$$+ \mathbb{1}_{\{W_{np}(wh,s',a') < W_p(wh,s',a')\}} \Big(J_{np}(wh, s', a') \frac{\phi_u(wh, s, a)}{u} \Big) (1 - f(\theta_p)) \Big] \Big\} da,$$

The firm's expected value of matching with a worker depends on the probability of matching with a specific worker of type (R, s, a) and the operating value, $J_{np}(R, s, a)$. A *np* firm can match with either a black or a white worker from the current unemployment pool. $\phi_u(bl, s, a)$ is the mass of unemployed black workers with productivity s and asset a, while $\phi_u(wh, s, a)$ is the corresponding mass of white workers. Thus, $\phi_u(bl, s, a)/u$ and $\phi_u(wh, s, a)/u$ are the densities of the unemployed black and white workers over s and a. These reflect the probabilities that a vacant *np* firm gets matched with an unemployed worker of type (R, s, a). Since unemployed white workers can potentially receive a competing offer from a p firm, the white worker will accept the *np* job and begin producing only if the *np* job provides the worker with a higher value, described by $(\mathbb{1}_{\{W_{np}(wh,s',a') \geq W_p(wh,s',a')\}})$, or if the worker did not receive a p firm offer, described by $(\mathbb{1}_{\{W_{np}(wh,s',a') < W_p(wh,s',a')\}}(1 - f(\theta_p)))$.

2.5.2 Vacant *p* firm

Vacant p firms pay a posting cost of κ_p and restrict their search to unemployed white workers. The probability of matching with an unemployed white worker is $q(\theta_p)$. Equation (17) describe the value of maintaining a p vacancy, V_p.

$$V_p = -\kappa_p + \Big(\frac{q(\theta_p)}{1+r}\Big) \sum_{s'} \pi_{ss'} \int_a \Big[\mathbb{1}_{\{W_p(wh,s',a') > W_{np}(wh,s',a')\}} \Big(J_p(wh, s', a') \frac{\phi_u(wh, s, a)}{u_{wh}} \Big)$$
$$+ \mathbb{1}_{\{W_p(wh,s',a') \leq W_{np}(wh,s',a')\}} \Big(J_p(wh, s', a') \frac{\phi_u(wh, s, a)}{u_{wh}} \Big) (1 - f(\theta_{np})) \Big] da \tag{17}$$

Since the vacant p firm only searches among white workers, the probability of matching with an unemployed white worker who has productivity s and assets a is represented by

$\phi_u(wh, s, a)/u_{wh}$. Similar to the case of np firms, a worker will accept the p job only if the offer is more favorable than other options or if they do not receive a competing offer from an np firm.

We assume that there is free entry of firms, and hence both p and np firms post vacancies until $V_p = 0$ and $V_{np} = 0$, respectively.

2.5.3 Producing *np* firm

The value of a producing np firm is described by Equation (18). The firm chooses capital k to maximize its lifetime value producing with the worker. The firm discounts its future value using the interest rate adjusted for the job destruction shock λ_{np}. Since the worker may experience an extreme wealth shock with probability ϵ_R, it changes the wage bargaining position of the worker to the firm. The future value of the firm incorporates this probability.

In the current period, $j(R, s, a)$ represents the profit earned, calculated as the output minus production costs. The worker's productivity, s, is a factor in the production function $sf(k)$. The matched firm produces $sf(k)$ units of output and incurs costs for capital rental and depreciation, represented by $(r + \delta)k$, as well as wage costs, $\omega_{np}(R, s, a)$.

$$
\begin{aligned}
J_{np}(R, s, a) &= \max_k \left\{ j(R, s, a) + \frac{1 - \lambda^{np}}{1 + r} \sum_{s'} \pi_{ss'} [(1 - \epsilon_R) J_{np}(R, s', a') + \epsilon_R J_{np}(R, s', 0)] \right\} \\
&\qquad \text{where} \\
j(R, s, a) &= sf(k) - (r + \delta)k - \omega_{np}(R, s, a).
\end{aligned} \tag{18}
$$

2.6 Producing *p* firm

Similar to a producing np firm, Equation (19) describes a producing p firm. The firm rents capital and discounts future profit accounting for the job destruction shock λ_p and the worker's extreme wealth shock ϵ_{wh}.

$$J_p(wh,s,a) = \max_k \Big\{ j(wh,s,a) + \Big(\frac{1-\lambda^p}{1+r}\Big) \sum_{s'} \pi_{ss'}[(1-\epsilon_{wh})J_p(wh,s',a') + \epsilon_{wh} J_p(wh,s',0)] \Big\}$$

where

$$j(wh,s,a) = sf(k) - (r+\delta)k - \omega_p(wh,s,a). \tag{19}$$

2.7 Wage bargaining

In each period, matched worker-firm pairs bargain for wages over the matched surplus. A worker has their matched surplus as $(W_i(R,s,a) - U_i^I(R,s,a))$ and a firm has its matched surplus as $J_i(Ra,s,a)$, where i denotes np or p. A worker's bargaining power ξ_R depends on the individual's race, and the firm's bargaining power is $1-\xi_R$. The resulting wage for workers at p and np firms are given by Equation (20) and Equation (21), respectively.

$$\omega_{np}(R,s,a) = \arg\max_{\omega_{np}} \Big(W_{np}(R,s,a) - U_{np}^I(R,s,a)\Big)^{\xi_R} J_{np}(Ra,s,a)^{1-\xi_R} \tag{20}$$

$$\omega_p(wh,s,a) = \arg\max_{\omega_p} (W_p(wh,s,a) - U_p^I(wh,s,a))^{\xi_{wh}} J_p(wh,s,a)^{1-\xi_{wh}} \tag{21}$$

Finally, we define the stationary equilibrium in Appendix A.

3 Calibration

A period in the model represents a quarter. We calibrate the benchmark model to match the relevant U.S. economy moments. We have two sets of parameters. The first group of parameters is chosen externally based on literature and empirical evidence without using model-generated data, while the second group of parameters is calibrated internally by simulating our model to match a set of relevant data moments. We set the share of black workers to be 19.1% in the model, with the remaining being white workers. Table 1 shows the internally calibrated parameter values and their targeted moments, as well as the externally chosen parameters and their sources.

Table 1: Calibration and targeted statistics

Parameter	Value	Description	Target statistics	data	model
Chosen internally					
β	0.9943	discount factor	K/Y	10.26	10.26
ι	1.3012	matching elasticity	job finding rate - black	0.4946	0.4946
κ_p	4.2622	p sector vacancy posting cost	job finding rate - white	0.6599	0.6599
κ_{np}	2.7350	np sector vacancy posting cost	market tightness	1	1
λ_{np}	0.0644	np sector job destruction shock	job separation rate - black	0.0644	0.0644
λ_p	0.0268	p sector job destruction shock	job separation rate - white	0.0380	0.0380
ξ_{bl}	0.1397	bargaining power - black	mean wage ratio	0.75	0.75
ξ_{wh}	0.2110	bargaining power - white	firm profit share	0.033	0.033
ϵ_{bl}	0.0179	extreme wealth shock - black	zero wealth share - black	0.18	0.18
ϵ_{wh}	0.0086	extreme wealth shock - white	zero wealth share - white	0.07	0.07
Chosen externally					
α	0.6600	elasticity of labor matching	Nakajima (2012)		
θ_n	0.2890	capital share of output	Nakajima (2012)		
δ	0.0150	quarterly depreciation rate	Nakajima (2012)		
ρ_s	0.9411	persistence of idiosyncratic shock	PSID		
σ_s	0.1680	standard deviation of idiosyncratic shock	PSID		
h	0.4000	UI replacement rate	Mitman and Rabinovich (2015)		
ξ	0.8433	maximum UI coverage	Setty and Yedid-Levi (2021) 48% median wage		
Pe	0.5385	probability of UI eligibility	maximum weeks of eligibility		

Notes: This table reports the parameters, their values, and descriptions. The top panel presents the parameters chosen internally by minimizing the distance between model generated moments and data. The last two columns of the top panel compare the targeted moments in the data and in the model simulations. The bottom panel reports the parameters chosen externally, their values, and description.

3.1 Preferences

We set the period utility function $u(c)$ to be $\log(c)$. The discount factor, β, is calibrated to match the quarterly capital-output ratio of 10.26, the value used by a number of studies including Den Haan, Judd, and Juillard (2010) and Carroll, Slacalek, Tokuoka, and White (2017). The resulting value of β is 0.9943, and the corresponding quarterly real interest rate is 1.3%.

3.2 Production

The worker-firm match produces according to a Cobb-Douglas production function, $f(k) = k^{\alpha}$. We choose α to be 0.289 and set the quarterly capital depreciation rate δ equal to 0.015 following Nakajima (2012).

3.3 Productivity and wealth shocks

We use hourly real wage from the Panel Study of Income Dynamics (PSID) to estimate the persistence, ρ_s, and the standard deviation, σ_s of the productivity process. Our estimation strategy closely follows Setty and Yedid-Levi (2021). We run a standard Mincer wage regression of log wage on the demographic controls, including education, labor market experience, race, marital status, year, and state fixed effects for a sample of males aged 25 years and above. We then use the obtained residuals to estimate an AR(1) regression by utilizing the panel dimension of the PSID data. The estimated regression is at a biennial frequency, given that the PSID data is available once in two years. We assign the quarterly adjusted coefficient of the AR(1) regression as the persistence of the idiosyncratic productivity process. The standard deviation of the productivity process corresponds to the standard deviation of the residuals from the AR(1) regression after adjusting for the model frequency. We estimate the quarterly persistence, ρ_s, to be 0.9411 and the corresponding standard deviation, σ_s, as equal to 0.1680.

Following Mukoyama (2010), our model also features extreme wealth shocks to capture the mass of people having zero wealth. The race-specific probability of losing one's wealth, ϵ_R, is calibrated to be 0.0179 for black workers and 0.0086 for white workers. They capture the empirical moments that around 18% of black workers and 7% white workers have zero wealth. (Nakajima, 2021).

3.4 Unemployment insurance

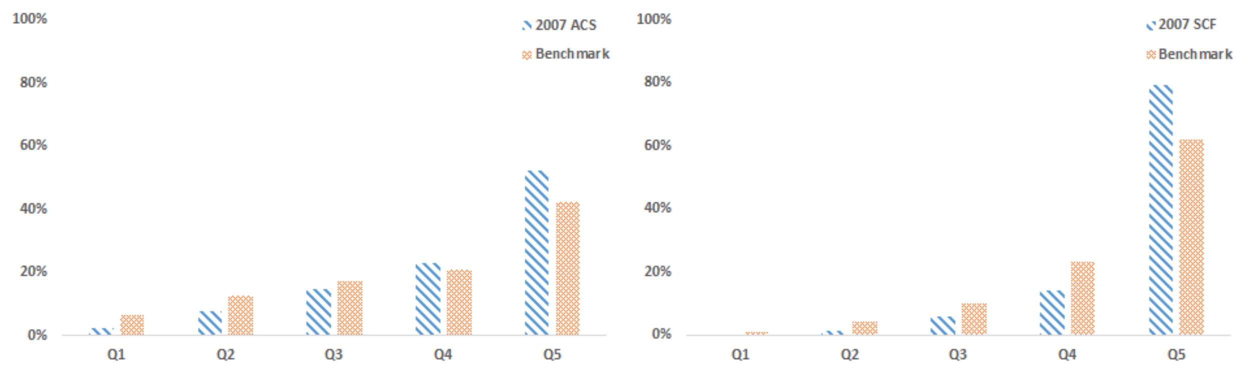
The unemployment insurance system in our model is characterized by the replacement rate, h, maximum insurance payout, χ, and the probability of maintaining the eligibility status, P_e. We choose the replacement rate, h, to be 0.4 along the lines of Shimer (2005), Mitman and Rabinovich (2015), and others. Following Setty and Yedid-Levi (2021), we calibrate the maximum payout χ to be 0.8433, which amounts to 48% of the median wage in the model. The eligibility probability P_e is chosen to be 0.5385 to generate an average unemployment benefit duration of 26 weeks, as in Mitman and Rabinovich (2015).

3.5 Labor search and wage bargain

The labor market turnover statistics are obtained from Cajner et al. (2017). The elasticity of the matching function, ι, targets the job finding rate of the black workers, and our calibrated value of 1.3012 is close to that of 1.25 in Den Haan et al. (2000) and Petrosky-Nadeau et al. (2018). We choose firm-type specific job destruction shocks λ_{np} and λ_p to match the job separation rates of black and white workers respectively. The ensuing values for λ_{np} and λ_p are 0.0644 and 0.0268, respectively.[5] The vacancy posting cost of prejudiced firms, κ_p, is chosen to match the job finding rate of white workers, while the posting cost of non-prejudiced firms, κ_{np}, is chosen to target the aggregate labor market tightness, θ, to be 1 following Wolcott (2021).[6] We find that the prejudiced firms pay a lot more than non-prejudiced firms to post their vacancies, with κ_p calibrated to be 4.2622, compared to κ_{np} taking a value of 2.735. The bargaining power of black workers, ξ_{bl}, is calibrated to target the average black-white racial wage ratio of 0.75 (Derenoncourt and Montialoux, 2021). The white worker's bargaining power, ξ_{wh}, is chosen to generate the average firm profit share of 3.3% as in Nakajima (2012). Consistent with our expectations, we find that the black

[5] All the black workers work only with np firms, and hence λ_{np} is exactly equal to the job separation rate of the black workers. On the other hand, white workers work in both p and np firms, and hence λ_p (0.0268) is smaller than the aggregate separation rate of the white workers (0.0380).

[6] Aggregate labor market tightness $\theta = \frac{v_{np}+v_p}{u_{bl}+u_{wh}}$.



(a) Labor income share (b) Wealth share

Figure 1: Labor Income and Wealth Distribution

Note: This figure compares the steady state model generated distributions of wealth and labor income with their empirical analogs. The empirical labor income and wealth distributions are estimated from the 2007 American Community Survey (ACS) and the 2007 Survey of Consumer Finance (SCF), respectively.

workers have a lower bargaining power compared to the white workers, with ξ_{bl} to be 0.1397 and ξ_{wh} to be 0.211.

3.6 Assessing the model as a quantitative theory of racial disparity

Our calibration successfully captures the racial gaps along three important dimensions: income, wealth, and labor market outcomes. We now discuss each of these dimensions in more detail before proceeding with the quantitative exercises examining the macroeconomic impact of racial discrimination.

First, the model successfully captures the overall household distribution of wealth and labor earnings as shown in Figure 1, even though we don't target these distributions explicitly. As with the majority of incomplete market models, we also face difficulty in generating the extreme concentration of wealth and labor income in the top quintile. On the other hand, we are much closer to the empirical distributions in the lower quintiles since we target the share of zero-wealth workers in our calibration.

Second, the model is able to capture the disparities in unemployment, labor income, and wealth between black and white workers. As targeted in the calibration, the model replicates

Table 2: Steady State Racial Inequality

Moments	Data	Model
Unemp rate (Black)	0.12	0.12
Unemp rate (White)	0.05	0.05
Mean wealth ratio	0.23	0.28
Median wealth ratio	0.17	0.33

Note: This table compares the steady state wealth and unemployment moments between black and white workers with the corresponding empirical data.

the empirical racial labor income gap and the empirical racial difference in the share of people at zero wealth. In addition to the targeted moments, Table 2 demonstrates that our model successfully captures the untargeted employment and wealth moments. Specifically, our model reproduces the 5% unemployment rate among white workers compared to 12% among black workers. Apart from the lower separation rate, white workers have a lower unemployment rate due to their access to the prejudiced sector. Our model results show that the p sector with the equilibrium market tightness of 0.4, though smaller than the np market tightness of 0.73, provides an important advantage for white workers by increasing their job-finding rate compared to black workers. On the wealth dimension, without targeting, the model generates a mean black-white wealth ratio of 0.28, close to 0.23 as in Kaplan, Violante, and Weidner (2014). However, the model understates the median wealth gap between black and white workers. The median black worker holds 33% of the wealth of the median white worker in our model compared to 17% in the data (Kaplan et al., 2014).

In sum, the model captures the racial inequalities across labor income, wealth, and unemployment outcomes. We next explore how racial discrimination in hiring contributes to these differences.

4 Steady state results

In this section, we first establish how a search framework sustains hiring discrimination in equilibrium. Then, we examine the steady-state impact of racial discrimination by comparing the benchmark economy to an alternative economy without hiring discrimination. Lastly, we explore the heterogeneous welfare implications associated with eliminating hiring discrimination.

4.1 Sustaining racial discrimination

The labor search-and-matching framework allows firms to earn profit from the surplus generated by the search frictions. This feature permits prejudiced and non-prejudiced firms to coexist in a competitive equilibrium. It contrasts with a frictionless canonical neoclassical model where prejudiced hiring will be driven out by competition if there is no inherent difference between black and white workers as described in Becker (1957). In particular, our benchmark model has p firms retaining a profit of 0.04 while np firms retain a profit of 0.03 in the steady state (see Column 1 of Table 3).

Next, we examine the steady-state interplay between discriminatory and non-discriminatory firms. Since discriminatory hiring remains profitable in the benchmark equilibrium, we gradually increase penalties by raising the vacancy posting costs for discriminatory firms until they are no longer profitable. Figure 2 displays the dynamics of employment, vacancy, and profits of the prejudiced and non-prejudiced firms. As κ_p rises, p firms become increasingly disadvantaged, gradually losing their profits, vacancy postings, and employment. Conversely, with fewer p firms competing in the market, np firms see a steady increase in profits, vacancy postings, and employment.

It is worth noting that the dynamics of p and np firms are not symmetric, given the differences in vacancy posting costs and job destruction shocks. As p firms' profit declines, the profit of np firms increases at a slower rate. Additionally, as np firms replace p firms, they recruit from both black and white workers, rather than only white workers displaced from p firms. This is mainly reflected in np firms' more elastic vacancy posting response.

In the limit, as κ_p approaches the total expected value of the p sector, discriminatory (p) firms almost completely exit the market, since posting vacancies exclusively for white workers

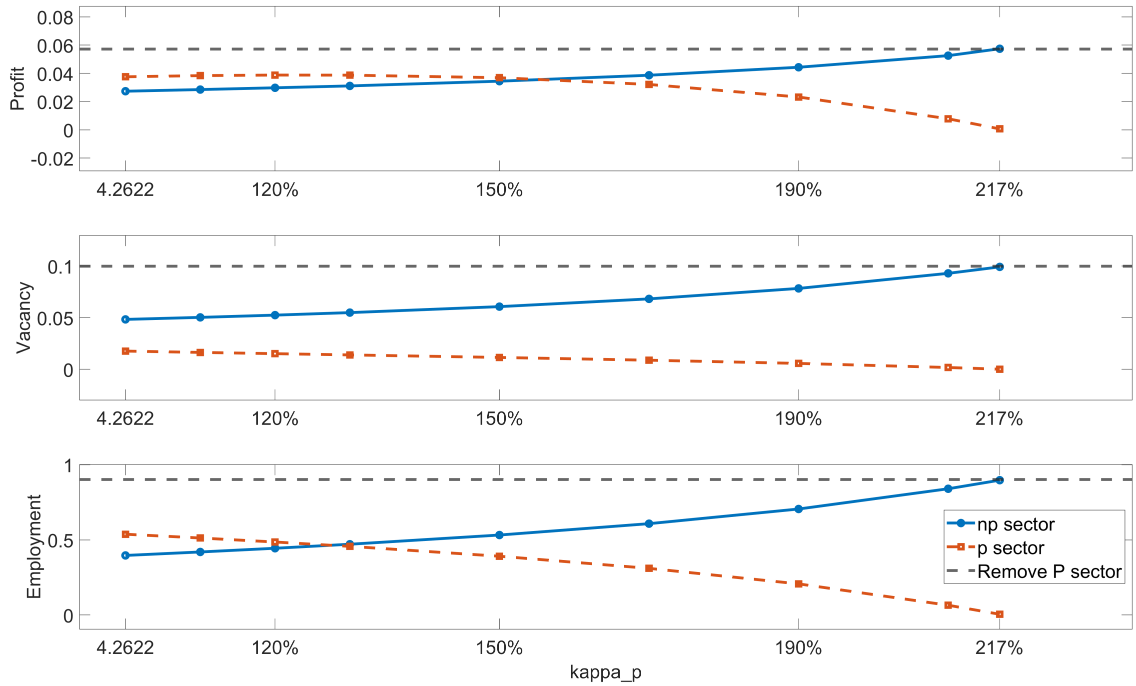


Figure 2: Penalizing discrimination

Note: This figure displays the dynamics between p and np firms as κ_p increases. The top panel plots the change in profit, the middle panel plots the change in vacancy posting, and the bottom panel plots the change in employment. The red dotted line depicts the dynamics of p firms, the blue solid line depicts the dynamics of np firms, and the gray dotted line depicts the limit where no p firm exists. The horizontal axes record the values of κ_p from the benchmark κ_p at 4.2622 to 217% of the benchmark value, at 9.2444. The vertical axes record the model-generated value of each variable.

becomes unprofitable. The value of κ_p at which p firms exit is 217% of the benchmark value of 4.26. Meanwhile, non-discriminatory (np) firms become nearly the sole employers in the economy. The gray dotted lines in Figure 2 illustrate a counterfactual steady state where we entirely remove p firms from the benchmark model. Thus, increasing κ_p in the limit asymptotically equals the alternative of completely eliminating p firms.

4.2 Impact of hiring discrimination on racial inequality

In this subsection, we compare the benchmark economy to one without prejudiced firms to illustrate the aggregate and distributional impact of discriminatory hiring. Table 3 presents the comparisons. All firms in the counterfactual models provide equal hiring opportunities to black and white workers. Column 2 removes the p firms from the model, which leaves all workers with equal job destruction shocks at the benchmark λ_{np}. In Column 3, we re-calibrate the job destruction shocks to race-specific and have λ_{wh} and λ_{bl} as race-specific job destruction shocks.[7] Re-assigning the job destruction shocks further isolates the impact of job separation.

The first panel shows the changes in racial employment, wage, and wealth disparities after removing prejudiced hiring. The first two rows describe the job separation rates. By construction, Column 2 equalizes job separation rates by race, while Column 3 retains the difference as the benchmark. The next two rows describe the job-finding rates. Since there is no p sector in the economy in Columns 2 and 3, the job-finding rates are equalized for black and white workers. White workers only have one sector for employment. Hence, their job-finding rate reduces. Black workers have more job opportunities as the np sector posts more vacancies; hence, their job-finding rate increases. Comparing Columns 2 and 3, the much lower job destruction shock for white workers in Column 3 results in fewer workers searching for jobs, which leads to higher job-finding rates than in Column 2. Altogether, it reduces the racial gap in the unemployment rate. In Column 2, the racial unemployment rate gap completely closes as job turnover equalizes. In Column 3, the unemployment rate gap closes from 7% to 3% because of the remaining racial difference in λ.

Turning to the wage impact, black workers can bargain for a higher wage rate as they receive more job opportunities when we remove discriminatory hiring. White workers, however, no longer have access to the exclusive p sector; their outside options are lower during bargaining, thus driving down their wage rate. As a result, the average black-to-white wage ratio increases from 75% in benchmark to 88% in Column 2 and to 86% in Column 3. We conclude that removing discriminatory hiring closes 52% (Column 2) to 44% (Column 3) of the average wage gap between black and white workers.

Additionally, removing discriminatory hiring reduces the wealth gap, with the mean

[7] In the benchmark economy, we structure firm-specific job destruction shocks (λ_{np} and λ_p) to match race-specific job separation rates. This counterfactual economy only has one type of firm. We assign white workers a job destruction shock, λ_{wh}, to be 0.038 and black workers a destruction shock, λ_{bl}, to be 0.0644 to keep black and white workers' job separation rates as in the calibration.

Table 3: Impact of hiring discrimination

Moments	Benchmark	Eliminate p firms	Race specific λ
		Households	
job separation rate - black	0.06	0.06	0.06
job separation rate - white	0.04	0.06	0.04
job finding rate - black	0.50	0.59	0.62
job finding rate - white	0.66	0.59	0.62
unemp rate - black	0.12	0.10	0.09
unemp rate - white	0.05	0.10	0.06
mean wage - black	1.60	1.96	1.82
mean wage - white	2.13	2.22	2.11
mean wage ratio	0.75	0.88	0.86
mean wealth ratio	0.28	0.33	0.33
median wealth ratio	0.33	0.44	0.44
		Firms	
p firm profit	0.04	-	-
np firm profit	0.03	0.06	0.06
p firm vacancy	0.02	-	-
np firm vacancy	0.05	0.10	0.07
p firm employment	0.54	-	-
np firm employment	0.40	0.90	0.94
		Labor Market	
p market tightness	0.40	-	-
np market tightness	0.73	1.02	1.12
		Aggregate Outcomes	
Y	3.06	2.95	3.06
K/Y	10.26	10.22	10.25
average wage	2.04	1.96	2.05
unemp rate	0.07	0.10	0.06

Note: This table compares the benchmark steady state with a counterfactual steady state without p firms. In the counterfactual model, all firms provide equal hiring opportunities to black and white workers and keep race-specific job destruction shock. All other parameters stay the same as benchmark calibration.

wealth ratio moving from 0.28 to 0.33 and the median wealth ratio increasing from 0.33 to 0.44. The result remains stable between Columns 2 and 3. We infer that discriminatory hiring explains about 7% of the mean wealth gap and 16% of the median wealth gap.

The remaining gaps in wage and wealth come from the bargaining power and extreme wealth shock disparities between black and white workers.[8]

The second panel displays the changes in firm attributes. We loosely refer to the one-sector economy without discriminatory hiring as *np* firms, though the Column 3 specification differs from the benchmark *np* firms in their job destruction shock. Without discriminatory firms, *np* firms' profit doubles, vacancy posting, and employment level increase. These changes result in the aforementioned advantages for black workers in the counterfactual economies. In Column 3, white workers' lower job destruction shock drives up the overall *np* employment and reduces vacancy postings compared to Column 2.

The third panel of Table 3 displays the labor market conditions. In response to the p firms exiting, more *np* firms endogenously enter the market. The labor market tightness of the *np* sector, θ_{np}, jumps from 0.73 in the benchmark to 1.02 in the equilibrium without p firms and 1.12 when we split λ by race. The ensuing market tightness is higher than the benchmark aggregate market tightness of 1.

The last panel of Table 3 describes the aggregate outcomes. With more *np* firms entering, the aggregate output stays relatively unchanged in Column 3. The capital-output ratio slightly decreases to 10.25. The economy-wide average wage increases to 2.05 from benchmark 2.04, and the aggregate unemployment rate decreases to 6%. However, Column 2 experiences a more significant reduction in output, average wage, and higher unemployment rate due to the overall higher job destruction shock that requires firms to frequently pay for vacancy posting costs rather than a resource for production.

Our results show that the presence of discriminatory firms can explain sizable fractions of income and wealth inequality. Penalizing prejudiced firms primarily improves the employ-

[8] Though not the primary purpose of this paper, we present the results after removing racial differences in bargaining power and extreme wealth shock in Appendix B.

ment opportunities and wage outcomes for the black workers; it also worsens the situation for the white workers. Removing p firms reduces the job-finding rate and, hence, the unemployment rate for white workers. In addition, they also lower the value of their outside option in wage bargaining, which, in turn, affects their income and wealth outcomes. To quantify the differential effects of removing discriminatory hiring, we next calculate the welfare changes experienced by the black and the white workers.

4.3 Welfare analysis

We follow Krusell, Mukoyama, and Şahin (2010) in measuring the welfare change for black and white workers by calculating the change in average consumption equivalence after removing discriminatory hiring.[9] We present the average welfare change between black and white workers by productivity types and by wealth quintiles in Table 4.

Overall, the economy experiences a 5.8% reduction in average welfare if we eliminate p firms and a 1.17% increase in average welfare if we separate the job destruction shocks by race. Once we remove discriminatory hiring, black workers experience an average welfare increase of between 6.89% and 10.94%. This is because of the rise in their job opportunities and higher wage rates. On the other hand, white workers encounter an average welfare loss of between 1.14% and 8.83%. This is because of the decrease in their wage rate and the increase in the unemployment rate.

Mid-panels in Table 4 present the heterogeneous welfare change for black and white workers by productivity types. Though the welfare reduction of eliminating prejudiced firms

[9] Under the benchmark model, let $V(e,R,s,a) = \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t log(c_t)$ be the maximal value of the individual with employment status e, race R, productivity s, and asset a. Under an alternate economy, let $\tilde{V}(e,R,s,a) = \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t log(\tilde{c}_t)$ be the maximal value of individuals with each corresponding state. We examine the welfare change between the two economies through consumption equivalence Ω, following the equation: $\mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t log((1+\Omega)c_t) = \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t log(\tilde{c}_t)$. With log utility, we derive $\Omega = \exp((\tilde{V} - V)(1-\beta)) - 1$. We aggregate the individual-level consumption equivalence, Ωs, using the distribution of the counterfactual economy to calculate the average welfare change. We aggregate over the counterfactual distribution rather than benchmark distribution because eliminating p firms in the model removes the distribution of white workers associated with the states of working at and unemployment from p firms. Aggregating over the benchmark distribution overstates the welfare change for white workers without accounting for the distribution shift.

is similar across productivity for white workers, the most considerable loss is for the lowest productive white workers at 9.03% when we remove p firms. In comparison, the highest productive workers lose the most at 1.19% when further adjusting the job destruction rate by race. In comparison, the most productive black workers have the highest welfare gain at 7.41% and 11.49% across the two counterfactual models.

Table 4: Heterogeneous welfare change

Average welfare gain (%)	Eliminate p firms		Race specific λ	
Overall	-5.83		1.17	
	Black	White	Black	White
	6.89	-8.83	10.94	-1.14
		by productivity		
Low	6.30	-9.03	10.31	-1.07
Mid	6.92	-8.83	10.98	-1.14
High	7.41	-8.61	11.49	-1.19
		by wealth		
Low 20%	6.85	-9.43	10.98	-1.13
40-60%	6.95	-8.95	10.94	-1.17
Top 20%	6.88	-8.14	10.72	-1.09

Note: This table compares the average consumption equivalence change from the benchmark steady state to the equilibrium where we eliminate p firms (Columns 1 and 2) and further adjust the job destruction shock to be race-specific (Columns 3 and 4). Low, mid, and high productivity corresponds to the lowest, middle, and highest value of idiosyncratic productivity s. The wealth quintiles are based on benchmark steady-state wealth distribution.

The bottom panels of Table 4 present the welfare change by wealth quintiles for black and white workers. Removing discriminatory firms benefits the mid-quintile black workers the most, at 6.95%, and the lowest-quintile black workers the most, at 10.98%, after adjusting the job destruction shocks by race. The most considerable reduction in welfare (9.43%) happens for the lowest quintile white workers in the model removing p firms and for mid-quintile white workers at 1.17% after adjusting for race-specific job destruction shocks.

5 Business cycle dynamics

In this section, we first document the racial disparities over the business cycle. Then, we introduce aggregate uncertainty in our benchmark model to quantify the role of hiring discrimination in generating disparate dynamics in the business cycle. Lastly, we discuss the welfare implications of hiring discrimination over the business cycle.

5.1 Racial disparities over the business cycles

Table 5 summarizes the business cycle disparities in the labor market between black and white workers. The top panel presents the dynamics of the racial unemployment rate gap, and the bottom panel presents the dynamics of the average wage. Cyclicality is measured by the correlation between the variable and real GDP. Volatility is calculated by the standard deviations of the variable relative to the standard deviation of real GDP.

Unemployment rate: We use monthly data from the Current Population Survey (CPS) from 1996 to 2014 to calculate the black-to-white unemployment rate difference. We then log the values and apply the HP filter with a smoothing parameter 1600 to extract cyclical components. We find that the racial unemployment rate gap is countercyclical, widening during recessions and narrowing during expansions. It has a relative volatility of 9.71.

Table 5: Business cycle statistics, US data, 1996-2014

	Cyclicality	Volatility
	Unemployment rate	
Black-White gap	-0.6255	9.7100
	Average wage	
Black	2.6041	2.5352
White	1.2729	2.0848

Note: This table provides business cycle statistics for the US. The unemployment rate was obtained from the Current Population Survey (CPS) from 1996 to 2014. Average wage statistics are constructed from the Panel Study of Income Dynamics (PSID) of the same period. All variables are logged and HP filtered with a smoothing parameter of 1600.

Wage: We rely on the individual data in PSID from 1996 to 2014 to construct a wage panel to calculate the cyclical properties of the average wage. This is because of the composition change of workers over the business cycles. Using aggregate wage data underestimates its cyclical properties (Stockman, 1983; Bils, 1985; Solon, Barsky, and Parker, 1994). For the same reason, we report the cyclical properties of the average wages for black and white workers separately rather than calculating the cyclical properties for a wage differential index. The wage cyclicality is calculated through a wage regression as the percentage change of average wage when real GDP increases by one percent after controlling for demographics. The wage volatility is calculated by the relative standard deviations of the year-to-year change in wage from the wage regression.[10] We find that wages for black workers are twice as cyclical as wages for white workers once we control for demographics. Black workers' average wage is more volatile (2.54) than white workers (2.08).

5.2 Augmented model with aggregate shocks

We introduce an aggregate total factor productivity (TFP) shock z to the benchmark steady-state model from Section 2. The TFP shocks follows an AR(1) process, $\log(z') = \rho_z \log(z) + \epsilon_z$, with $\epsilon_z \overset{iid}{\sim} N(0, \sigma_z^2)$. The output of the matched firm-worker pairs depends on the realizations of both aggregate and idiosyncratic productivity shocks and is given by $zsf(k)$.

With the introduction of aggregate shocks, the state space expands to include aggregate states (z, μ), where μ is the distribution of workers across employment status (e), race (R), idiosyncratic productivity (s), and asset (a). The next period's aggregate distribution μ' is

[10] We conduct wage regression by regressing the change in individual log wage on the change in log GDP, after controlling for demographic factors. Specifically, we follow Bils (1985), Solon et al. (1994), and Devereux (2001) and run the regression:

$$\Delta \log w_{it} = \alpha + \beta \Delta \log Y_t + \gamma x_{it} + \nu_t + \upsilon_s + \epsilon_{it} \tag{22}$$

where Y_t refers to real GDP. Demographic variables x_{it} include gender, education, labor market experience, and marital status. We also include year fixed effects, ν_t, and state fixed effects, υ_s. We measure cyclicality using coefficient β from the regression. The volatility is the standard deviation of the year fixed effects, ν_t. We then adjust the estimation to quarterly frequency.

determined by (z, μ), and the law of motion is given by $\mu' = \Gamma(z, \mu)$.

We follow Cooley, Prescott, et al. (1995) and Boppart, Krusell, and Mitman (2018) and choose the persistence parameter ρ_z to be 0.95, while the standard deviation σ_z is set to 0.015. All other parameters stay the same as in Table 1. This gives us an aggregate output volatility of 0.02 and a first-order auto-correlation of 0.73.

We obtain the stochastic equilibrium of our model by using the sequence space method of Boppart et al. (2018). We first solve non-linearly for the perfect foresight transitions to a single small MIT shock, i.e., an unexpected shock to the aggregate TFP. We then use the solved impulse responses as the numerical derivatives with respect to the initial TFP shock. Using these derivatives, we simulate the stochastic equilibrium by generating the TFP realizations and calculating the corresponding model moments over the business cycle as a linear combination of the impulse response and the TFP realizations.[11]

Table 6: Business cycle model vs data

	Cyclicality		Volatility	
	Data	Model	Data	Model
	Unemployment rate			
Black-White gap	-0.6255	-0.6731	9.7100	0.3009
	Average wage			
Black	2.6041	1.0749	2.5352	1.0755
White	1.2729	0.9984	2.0848	0.9985

Note: This table compares the data moments and the benchmark generated moments on the black-white unemployment and wage gaps over the business cycles.

Table 6 compares data and model moments on unemployment and wages. Similar to standard search models, the stochastic dynamics of our model are under the influence of the Shimer Puzzle (Shimer, 2005). The augmented benchmark model generates similar cyclicality in the unemployment rate gap as data but much less volatility in the unemployment rate gap. Regarding the average wage, the model has lower cyclicality for both black and

[11] This method hinges on the assumption that the business cycle dynamics can be well approximated as a linear system. In Appendix C, we demonstrate the validity of this assumption by establishing the symmetry of the impulse responses to 1% positive and negative TFP shocks.

white workers and less pronounced differences in volatility. However, qualitatively, we have a higher wage cyclicality and volatility for black workers than for white workers.

5.3 Impact of hiring discrimination over business cycle

We compare the benchmark dynamics with the counterfactual model without p firms to examine the role of discriminatory hiring over aggregate shocks.[12]

5.3.1 Impulse responses

Figure 3 plots the response of black and white workers' labor market, wealth, and consumption outcomes after a 1% unanticipated expansionary TFP shock. We compare the benchmark model response to the counterfactual model without p firms. Overall, our models generate countercyclical unemployment rates and procyclical wage, wealth, and consumption movements.

In the model without p firms, black workers' unemployment rate decreases less than that of the benchmark economy after the expansionary shock. This implies that their unemployment rate is less volatile without p firms. This is because np firms have to compete against p firms for hiring, so they post more vacancies, providing more opportunities to all workers. For white workers, the difference is much smaller between the benchmark and the model without p firms. Interestingly, their recovery in the counterfactual model is much faster than in the benchmark model. This is because the p sector has a low job destruction shock. Once hired, white workers are less likely to lose their jobs, hence a slower rate to a steady state.

The average black-white wage and wealth ratios increase more after the expansionary shock in the benchmark model than without discriminatory firms. This suggests more volatile procyclical wage and wealth responses for black workers than for white workers with the presence of p firms. Lastly, We don't observe a discerning difference in the consumption responses with and without p firms.

[12] As with Table 3, the counterfactual economy is a one-sector economy with only np firms. We do not further adjust race-specific destruction shocks.

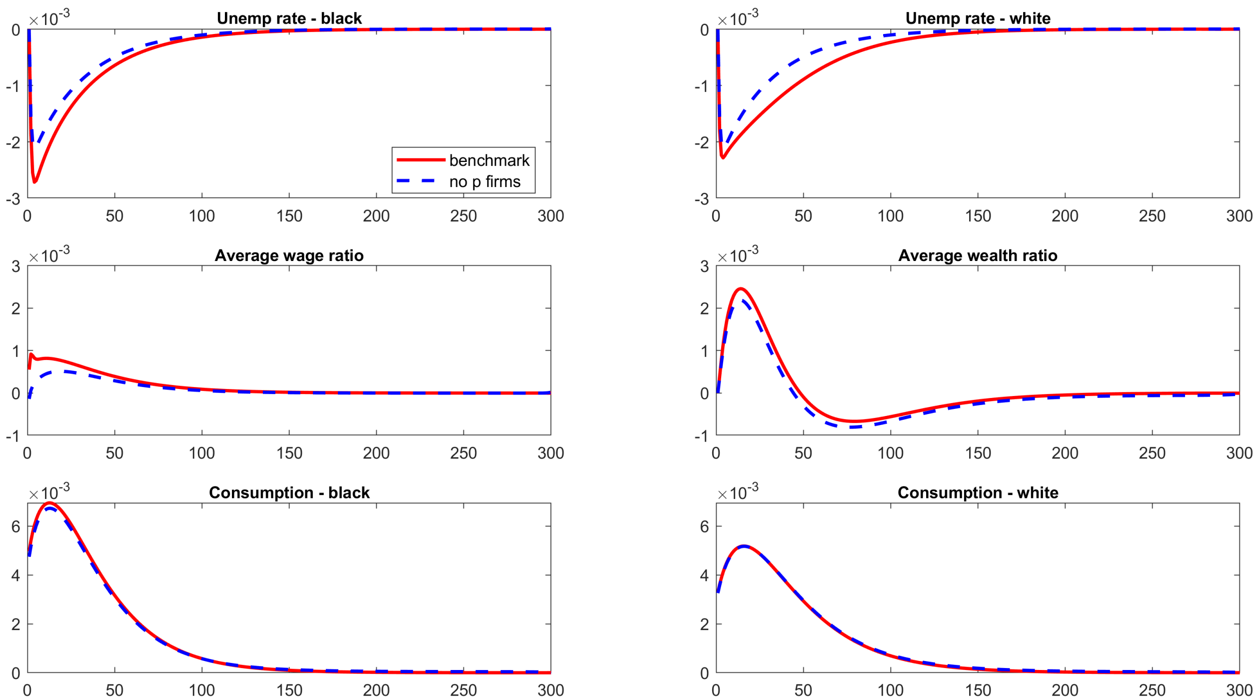


Figure 3: Impulse responses

Note: This figure plots the impulse response functions of unemployment rates, black-white average wage and wealth ratios, and aggregate consumption between black and white workers to a one percent increase in aggregate TFP at date zero. The red solid line denotes the responses from the benchmark model, and the blue dashed line denotes the responses from the counterfactual model without p firms.

5.3.2 Stochastic simulation

We simulate the stochastic equilibrium of the economy over 10,000 periods under aggregate TFP shocks, comparing outcomes with and without p firms. While impulse responses to an MIT shock capture the transition path following a one-time disturbance, the stochastic equilibrium focuses on the economy's short-term responses to continuous aggregate shocks. The results are summarized in Table 7.

The counterfactual equilibrium without p firms eliminates the racial unemployment rate gap, resulting in the disappearance of its cyclical properties. Similarly, the racial differences in the cyclicality and volatility of average wages are largely reduced. As shown in Table 7, in the benchmark model, the black-white unemployment rate gap exhibits strong countercyclicality (-0.6731) and volatility (0.3009), both of which vanish in the absence of p firms. For average wages, the cyclicality for black workers decreases from 1.0749 in the benchmark to 1.0131 without p firms, while for white workers it increases slightly from 0.9984 to 1.0115. Similarly, the volatility for black workers falls from 1.0755 to 1.0139, while for white workers it increases from 0.9985 to 1.0116. This convergence demonstrates that hiring discrimination is a primary driver of the labor market's cyclical disparities between black and white workers. These findings align with Cajner et al. (2017), who argue that demographic differences alone cannot fully account for observed racial disparities over the business cycle.

We further examine the behaviors in the cyclical properties of the average black-to-white wealth ratio and the average black-to-white consumption ratio. Other than the cyclicality of the average wealth ratio, the cyclical properties of the racial gaps in all other dimensions are reduced after discriminatory hiring is removed.

We further examine the cyclical properties of the average black-to-white wealth ratio and consumption ratio. In the benchmark model, the cyclicality of the average wealth ratio is 0.2028, which changes slightly to 0.2054 without p firms, while its volatility decreases from 0.1611 to 0.1466. For the average consumption ratio, the cyclicality decreases marginally from 0.9717 to 0.9695, and the volatility drops more significantly from 0.1861 to 0.1659.

Table 7: Impact of hiring discrimination on business cycle racial gaps

	Cyclicality		Volatility	
	Benchmark	No p firms	Benchmark	No p firms
	Unemployment rate			
Black-White gap	-0.6731	0.0000	0.3009	0.0000
	Average wage			
Black	1.0749	1.0131	1.0755	1.0139
White	0.9984	1.0115	0.9985	1.0116
	Wealth ratio			
Wealth ratio	0.2028	0.2054	0.1611	0.1466
	Consumption ratio			
Consumption ratio	0.9717	0.9695	0.1861	0.1659

Note: The top panel compares the black-white unemployment rate, wage, consumption, and wealth gaps over the business cycles between the benchmark model and model without p firms.

These results show that, aside from the cyclicality of the wealth ratio, the cyclical properties of racial gaps across all other dimensions are notably reduced when discriminatory hiring is eliminated.

In summary, p firms drive racial disparities in the labor market over the business cycle. The black-white unemployment rate gap, countercyclical in the benchmark, vanishes without p firms. Wage cyclicality and volatility for black workers also decline, converging toward those of white workers. While the wealth ratio's cyclicality rises slightly, its volatility and that of the consumption ratio decrease. These findings indicate that hiring discrimination is a key factor shaping racial differences in the cyclical properties of the labor market and economic outcomes.

5.4 Welfare disparities in business cycles

Lastly, we examine the business cycle welfare implications of removing hiring discrimination. We simulate the economy for 10,000 periods and compute the long-run average welfare for each individual type, following Cho and Ma (2023). The welfare measure is calculated as average consumption equivalence described in Section 4.3 over the simulation periods. We present the results in Table 8.

Table 8: Heterogeneous welfare change in business cycles

Average welfare gain (%)	Eliminate p firms	
Overall	-0.01	
	Black	White
Average	0.02	-0.01
by productivity		
Low	0.00	-0.01
Mid	0.02	-0.01
High	0.02	-0.02
by wealth		
Low 20%	0.01	-0.01
40-60%	0.02	-0.02
Top 20%	0.03	-0.02

Note: This table compares the average consumption equivalence change from the benchmark model to the one without p firms in business cycles. We simulate the economy for 10,000 periods and calculate the long-run average welfare for each individual type. Low, mid, and high productivity corresponds to the lowest, middle, and highest value of idiosyncratic productivity s. The wealth quintiles are based on benchmark steady-state wealth distribution.

The economy experiences an average of 0.01% welfare decrease after removing prejudiced firms. This is much less than the welfare change in the steady state in Table 4, primarily because workers are risk averse. All workers experience a decrease in unemployment rate volatility, and white workers experience an increase in wage volatility that somewhat counters the changes in other dimensions. On average, black workers experience a modest welfare gain of 0.02%, whereas white workers face a slight welfare loss of 0.01%. Among white workers, those with high productivity and those in the top 20% of the wealth distribution lose the most (0.02%). In contrast, black workers in the top wealth quintile benefit the most, with an average welfare gain of 0.03%.

6 Conclusion

This study examines the effects of racial hiring discrimination within a frictional labor market on employment, wage disparities, and wealth accumulation between black and white workers in the U.S. We develop a search-and-matching model incorporating firms with and without racial prejudices alongside race-specific pathways for wealth accumulation. Our findings reveal that racial discrimination in hiring significantly exacerbates wage, unemployment, and wealth gaps in steady state and business cycles. Moreover, discriminatory hiring disproportionately consigns black workers to the lower end of the wealth spectrum. Contrary to conventional discrimination theories, our analysis suggests that discriminatory hiring persists as an equilibrium outcome within frictional markets. Eliminating these discriminatory factors results in a decrease in overall welfare. Our findings shed light on the enduring nature of Black-White racial disparities in the U.S., offering insights into the interplay between discrimination, labor market dynamics, and wealth accumulation.

Appendix A Stationary Equilibrium

A stationary equilibrium consists of

1. Value functions of workers $\left\{W_{np}(R,s,a), W_p(wh,s,a), U^I_{np}(R,s,a), U^I_p(wh,s,a), U^N(R,s,a)\right\}$, and firms $\left\{V_{np},\ V_p,\ J_{np}(R,s,a),\ J_p(wh,s,a)\right\}$
2. Corresponding asset policy functions of workers $\left\{g_{np}(R,s,a),\ g_p(wh,s,a),\ g^I_{np}(R,s,a),\ g^I_p(wh,s,a),\ g^N(R,s,a)\right\}$, along with the capital choice of producing firms $\left\{k_{np}(R,s,a),\ k_p(wh,s,a)\right\}$ and vacancy choice of vacant firms $\left\{v_{np},\ v_p\right\}$
3. Wages $\left\{\omega_{np}(R,s,a),\ \omega_p(wh,s,a)\right\}$
4. Aggregate interest rate and labor market tightness $\left\{r,\ \theta_{np},\ \theta_p\right\}$
5. Unemployment insurance tax rate τ
6. Dividends d
7. Distribution over employment status (e), race (R), idiosyncratic productivity (s), and wealth (a), given by $\mu(e,R,s,a)$

such that:

1. $\left\{W_{np}(R,s,a),\ W_p(wh,s,a),\ U^I_{np}(R,s,a),\ U^I_p(wh,s,a),\ U^N(R,s,a)\right\}$ are the solutions to the worker's optimization problems (equations 2, 4, 6, 8, 10, 12, and 14), and $\left\{g_{np}(R,s,a),\ g_p(wh,s,a),\ g^I_{np}(R,s,a),\ g^I_p(wh,s,a),\ g^N(R,s,a)\right\}$ are the associated optimal decision rules for asset choice.
2. $\left\{J_{np}(R,s,a),\ J_p(wh,s,a)\right\}$ are the solutions to the producing firm's problems (equations 18 and 19), and the corresponding capital choice is given by $\left\{k_{np}(R,s,a), k_p(wh,s,a)\right\}$.
3. Free entry of vacant firms, i.e., $V_{np} = 0$ and $V_p = 0$ determines the number of vacancies $\left\{v_{np},\ v_p\right\}$, and hence labor market tightness $\left\{\theta_{np},\ \theta_p\right\}$.

4. Aggregate demand for capital equals aggregate supply, which in turn determines the interest rate r.

5. Wages $\left\{\omega_{np}(R,s,a),\ \omega_p(wh,s,a)\right\}$ are determined by Nash bargaining between the worker and the firm.

6. Unemployment insurance tax rate τ solves to balance the government budget.

7. Dividend d is the total flow profits of producing firms, net of total posting costs of vacant firms.

$$d = -\kappa_p v_p - \kappa_{np} v_{np} + \int 1_{e=1,np}\ j_{np}(R,s,a) d\mu + \int 1_{e=1,p}\ j_p(wh,s,a) d\mu \tag{A.1}$$

where j_{np} and j_p refer to the flow profits of np and p firms respectively.

$$\begin{aligned} j_{np}(R,s,a) &= sf(k_{np}) - (r+\delta)k_{np} - \omega_{np} \\ j_p(wh,s,a) &= sf(k_p) - (r+\delta)k_p - \omega_p \end{aligned} \tag{A.2}$$

8. The distribution $\mu(e,R,s,a)$ is invariant and is consistent with the optimal decision rules of capital choice, the law of motion of idiosyncratic productivity, and the labor market flows.

Appendix B Comparing the impact of bargaining power and extreme wealth shock

Table B.1 compares the benchmark model to models that remove non-market disparities, particularly in equalizing racial bargaining power and extreme wealth shocks. Equalizing black workers' bargaining power to white workers (Column 2, $\xi_{bl} = \xi_{wh}$) depresses black workers' job-finding rate but directly raises their bargained wage outcomes. This is because non-prejudiced firms retain less profit, hence posting fewer vacancies. On the net, it also reduces white worker's job-finding rate and average wage rate. As a result, the average wage gap shrinks to 19% (with a wage ratio of 81%), explaining about 24% of the racial wage gap.

In Column 3 ($\epsilon_{bl} = \epsilon_{wh}$), we assign black workers the same conditions in accumulating wealth as white workers. The effect resembles assigning a higher bargaining power to black workers. This is because of the importance of personal wealth in partial self-insurance against uncertain adverse outcomes (Nakajima, 2012). With a lower probability of losing their wealth, black workers can accumulate more personal wealth. Higher personal wealth gives black workers higher reservation value when bargaining with firms. Effectively, black workers can bargain for higher wage outcomes (1.66 compared to 1.60 in the benchmark model). Similar to directly assigning a higher bargaining power, the resulting job-finding rates decrease, though to a smaller extent. The smaller extreme wealth destruction rate also translates into better aggregate capital accumulation and increased aggregate output. It spills over to an increase in the average wage rate for all. Though it has a much less impact on the unemployment rate gap, it raises the average black-to-white wage ratio to 77% and reduces the wage gap to 23%, explaining 8% of the racial wage gap. Since it directly raises the wealth position of black workers, the mean and median black-to-white wealth ratios increase drastically (77% and 88% from the benchmark 28% and 33%).

Appendix C Impulse responses

We follow Boppart et al. (2018) to simulate the business cycle moments of the model from the derivatives of the impulse response functions. For the impulse response functions to represent the numerical derivative, the magnitude of the MIT shock should be small. This method also requires the business cycle dynamics to be well approximated as a linear system. Figure C.1 presents the impulse response functions for the benchmark model to a 1% positive and negative TFP shock at date 0. The shock gradually returns to a steady state with a persistence of 0.95. Our model produces symmetric impulse responses across all variables.

Table B.1: Aggregate impact of racial disparities from non-market factors

Moments	Benchmark	$\xi_{bl} = \xi_{wh}$	$\epsilon_{bl} = \epsilon_{wh}$
Households			
job separation rate - black	0.06	0.06	0.06
job separation rate - white	0.04	0.04	0.04
job finding rate - black	0.50	0.43	0.48
job finding rate - white	0.66	0.64	0.66
unemp rate - black	0.12	0.13	0.12
unemp rate - white	0.05	0.05	0.05
mean wage - black	1.60	1.71	1.66
mean wage - white	2.13	2.12	2.15
mean wage ratio	0.75	0.81	0.77
mean wealth ratio	0.28	0.29	0.77
median wealth ratio	0.33	0.33	0.88
Firms			
p firm profit	0.04	0.04	0.04
np firm profit	0.03	0.02	0.02
p firm vacancy	0.02	0.02	0.02
np firm vacancy	0.05	0.04	0.05
p firm employment	0.54	0.58	0.56
np firm employment	0.40	0.35	0.38
Labor Market			
p market tightness	0.40	0.46	0.43
np market tightness	0.73	0.60	0.69
Aggregate Outcomes			
Y	3.06	3.05	3.08
K/Y	10.26	10.25	10.45
average wage	2.04	2.05	2.06
unemp rate	0.07	0.07	0.07

Note: This table compares the benchmark steady state to a model with equal bargaining power $\xi_{bl} = \xi_{wh}$ and a model with equal extreme wealth shock $\epsilon_{bl} = \epsilon_{wh}$.

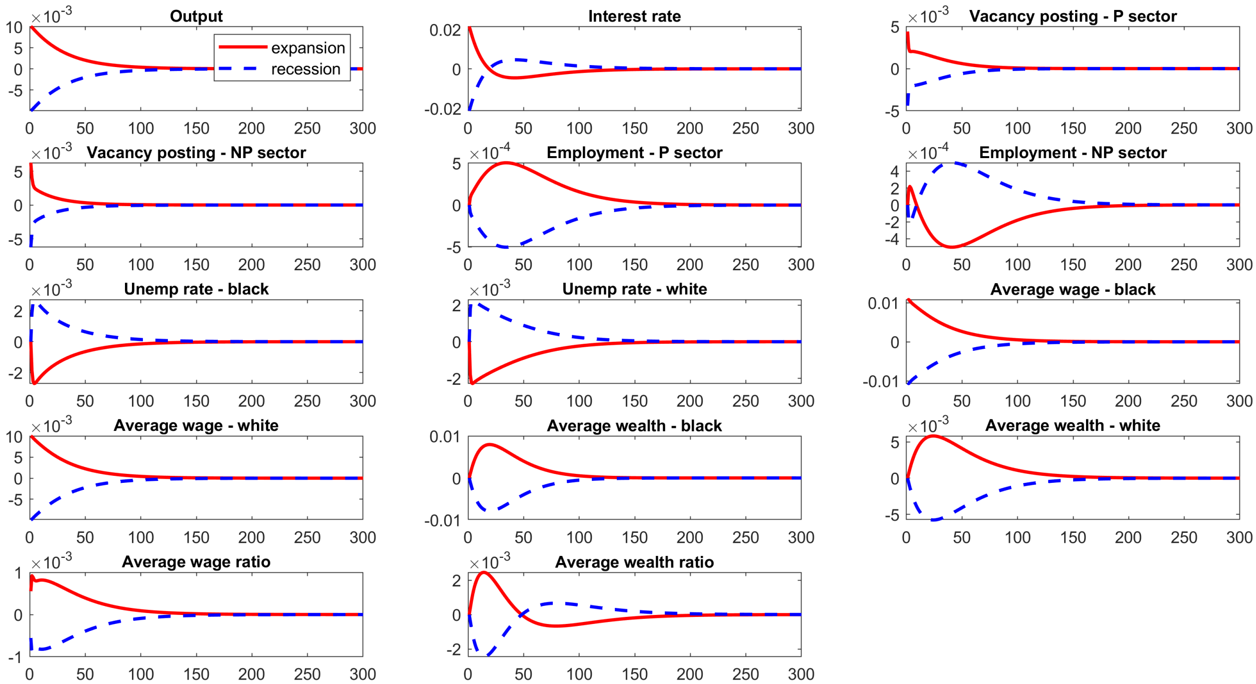


Figure C.1: Comparing impulse responses

Note: This figure plots the impulse response functions of the benchmark economy to a one percent increase and a one percent decrease in aggregate TFP at date zero. The red solid line denotes the responses to the expansionary shock, and the blue dashed line denotes the responses to the recessionary shock.

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