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

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September 2024
preliminary draft

Abstract

This paper investigates how racial discrimination in hiring impacts employment, wages, and wealth between black and white workers. We develop a labor search-and-matching model that includes both black and white workers and firms with and without racially biased hiring practices. We find that labor market frictions allow discriminatory practices to persist as an equilibrium outcome. These practices contribute significantly to the black-to-white wage and wealth gaps, explaining approximately 44% of the average wage gap and 16% of the median wealth gap. Moreover, discriminatory hiring exacerbates unemployment and wage volatility for black workers, leading to countercyclical racial unemployment gaps and procyclical racial wage disparities. Removing prejudiced firms reduces these disparities and enhances black workers' welfare as well as the overall economy's 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 viewed as inefficient or a supplement to information asymmetry.[1] Thus, market competition and information updates should drive out discrimination in the long run. However, much empirical evidence demonstrates that discriminatory practices persist in various markets and cause extensive racial disparities.[2] Only recently has research begun to examine racial disparities in macroeconomics.[3] Yet, the role of discriminatory practices has been largely overlooked. Identifying a general equilibrium theory that explains the sustaining discrimination and its consequences has crucial implications for understanding the macroeconomic impact of racial disparities and policymaking.

This paper develops a labor search-and-matching framework that captures the persistence of hiring discrimination based on race. Importantly, we demonstrate that hiring discrimination explains about 44% of the black-to-white average wage gap and 16% of the racial median wealth gap. Furthermore, discriminatory hiring practices intensify unemployment and wage volatility for black workers, leading to a countercyclical racial unemployment gap and a procyclical racial wage disparity. Specifically, we construct a heterogeneous agent labor market search-and-matching model. Firms compete against each other to hire workers to produce, although prejudiced firms only hire white workers. Individuals are *ex-ante* different in race, which leads to differences in bargaining power and the probability of experiencing a wealth destruction shock. All workers compete for employment opportunities, although white workers have extra opportunities with prejudiced firms. Matched worker-and-firm pairs bargain for a wage rate to maximize joined matched surplus. Upon calibration, our

[1] See Becker (1957) and summaries of Lang and Spitzer (2020) on taste and statistical discrimination theories.

[2] See for example Couch and Fairlie (2010); Biddle and Hamermesh (2013); Kuhn, Schularick, and Steins (2020); Derenoncourt and Montialoux (2021). Resume studies reveal the persistence of discriminatory practices based on race after controlling for job candidate qualities (e.g. Bertrand and Mullainathan, 2004). The labor income and wealth gaps between black and white households persist, even after the Civil Rights Movement Era (e.g. Cajner, Radler, Ratner, and Vidangos, 2017; Derenoncourt, Kim, Kuhn, and Schularick, 2023). Small and Pager (2020) suggests that discrimination reinforces itself across various domains and is 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).

model endogenously generates a lower job-finding rate, a higher unemployment rate, and a lower bargained wage for black workers. Without further financial frictions, our model produces significant differences in wealth accumulation between black and white workers.

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, these firms slowly reduce their vacancy postings and employment, while their profits adjust in accordance with 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 have sufficient profit margins to absorb higher vacancy posting costs, even with the existing market competition.

Moreover, hiring discrimination perpetuates the equilibrium economy through firms' vacancy postings. Prejudiced firms post vacancies in competition against non-prejudiced firms for each unemployed white worker. As a result, they drive up the wage rates for white workers across the economy. As non-prejudiced firms pay higher premiums for white workers, their expected profits decrease, leading to their overall fewer vacancy postings. This reduction in non-prejudiced job openings directly reduces employment opportunities for black workers, contributing to lower wages and higher unemployment rates, which translates into adverse wealth accumulation.

In a counterfactual economy, eliminating prejudiced firms equalizes the racial unemployment rate and vastly reduces the wage gap. In particular, prejudiced hiring accounts for over 40% of the racial wage gap. Moreover, we find that high-productive and low-wealth-quintile black workers experience the most considerable welfare improvement from removing prejudiced firms. As white workers losing the additional sector providing exclusive employment opportunities, their average wage declines and unemployment rate increase. As a result, white worker's experience a modicum welfare decrease in the steady state.

We further introduce aggregate fluctuations to the economy and show that hiring dis-

crimination leads to 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 procyclical and volatile racial wage ratio. Upon removing prejudiced firms, the racial unemployment rate disparities largely reduce, and the volatility and cyclicality of wage rate disparity significantly diminishes. This provides theoretical evidence to Cajner et al. (2017) that non-market demographic factors alone do not fully explain the business cycle differences between black and white workers.

Lastly, we examine the welfare change between black and white workers when discriminatory hiring contributes to more volatile labor market outcomes for black workers. We compare the average consumption equivalence of workers during business cycles after removing prejudiced firms. All workers benefit from a less volatile economy without discriminatory firms. Black workers gain an average of 0.46% in welfare compared to that of 0.73% for white workers. Different from steady state welfare value, among the black workers, the high-productive and high-wealth gain the most. Among the white workers, the low productive and low wealth white workers gain the most.

This paper contributes to the rising discussion on the aggregate impact of inequality by focusing on the disparate conditions and outcomes of white and black workers. Numerous studies have documented racial differences in pay and employment opportunities (e.g. Black, 1995; Coate and Loury, 1993; Rosén, 1997; Bertrand and Mullainathan, 2004). Fewer studies examine the patterns between black and white workers over macroeconomic fluctuations. Among the work, Couch and Fairlie (2010) shows that black workers are last hired in the economic upturn and first fired in the downturn. Biddle and Hamermesh (2013) documents that the discriminatory wage gap between black and white workers is procyclical. Cajner et al. (2017) shows much higher unemployment rate volatility and a higher rate of involuntary part-time employment for black workers. Daly, Hobijn, and Pedtke (2020) suggests that the harsh employment opportunities for black workers are driving up the racial earnings gap.

An emerging strand of literature documents the racial disparities in wealth holdings (e.g.

Derenoncourt et al., 2023; Derenoncourt, Kim, Kuhn, and Schularick, 2022; Kuhn et al., 2020; Barsky, Bound, Charles, and Lupton, 2002; McIntosh, Moss, Nunn, and Shambaugh, 2020). Recently, Derenoncourt et al. (2023) provide a historical account of wealth segregation between black and white Americans over the past 150 years. Boerma and Karabarbounis (2021) and Aliprantis et al. (2023) examine the impact of discriminatory history on earnings, bequest, and capital returns in a steady-state model without aggregate risks. Given the racial wealth difference, Ganong et al. (2020) shows that income risks are transmitted differently to individuals of different racial groups. With such understandings, Bartscher, Kuhn, Schularick, and Wachtel (2021) and Lee et al. (2021) discuss the disparate consequences of monetary policy on workers of different race groups.

Germane to our project, Nakajima (2021) creates a search-and-matching model examining the role of monetary policies in perpetuating racial differences in the labor market. Different from Nakajima (2021), our model intentionally differentiates discriminatory firms from non-discriminatory firms in the labor market hiring process and examines the impact of discriminatory hiring behaviors on black workers and its spillover effects on the rest of the economy. Our analysis establishes the first theoretical understanding of the interplay of hiring discrimination on labor and wealth disparities in the long run and over the business cycles.

In a broader context, this proposed project contributes to the growing discussion on the distributional impact of economic growth and macroeconomic policies by focusing on the heterogeneous outcomes of white and black workers. It joins Caballero and Hammour (1994), Jaimovich and Siu (2020), and Heathcote, Perri, and Violante (2020) in providing evidence that recessions disproportionately hurt disadvantaged individuals. Borella, De Nardi, and Yang (2018) show that introducing gender differences in a theoretical life-cycle model offers a better model fit to the data. This paper will provide insights into how racial difference allows a better fit for search models over the business cycle. Theoretically, Krusell and Smith (1998) conclude that heterogeneity in wealth does not alter business cycle fluctuations. Jang,

Sunakawa, Yum, et al. (2020) show that heterogeneity passes to large aggregate fluctuations when introducing non-convexity in budget constraint through progressive tax. This paper identifies that racial wedges in labor search transmit individual risk and heterogeneity to aggregate fluctuations.

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

In this section, we present 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 separation rates. 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 terms of their asset holdings. They have access to risk-free assets, and the workers can save using these 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. Taken together, workers are heterogeneous across race (R), labor market status (e), idiosyncratic productivity (s), and wealth (a), and the endogenous distribution of workers is given by $\mu(e, R, s, a)$.

2.2 Labor market search and matching

The total number of unemployed workers u is the sum of unemployed black (u_{bl}) and white (u_{wh}) workers. The number of np vacancies available is v_{np}, while the number of p firm vacancies is v_p. Since the non-prejudiced firms search among both black and white unemployed workers, the non-prejudiced market tightness is given by $\theta_{np} = v_{np}/u$. On the other hand, prejudiced firms employ only white unemployed workers, and hence the prejudiced market tightness is $\theta_p = v_p/u_{wh}$. Following Den Haan, Ramey, and Watson (2000) and Petrosky-Nadeau, Zhang, and Kuehn (2018), unemployed workers and vacant firms match via 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, probability of eligibility P_e, and maximum eligibility 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 as well. Unemployment benefits are funded through 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 depends 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 receiving unemployment benefits earns a value of $U^N(R, s, a)$ 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

$$W_{np}(\mu; R, s, a) = \max_{c,a'>0} \Big\{ u(c) + \beta \mathrm{E}_{\epsilon_R} \sum_{s'} \pi_{ss'} [\underbrace{\lambda_{np} U^I_{np}(\mu'; R, s', a')}_{\text{expected unemployment value}} + \underbrace{(1-\lambda_{np}) W_{np}(\mu'; R, s', a')}_{\text{expected continuing employed value}}] \Big\} \tag{2}$$

s.t.

$$c + a' = (1-\tau)\omega_{np}(\mu; R, s, a) + (1+r)a + d$$

An employed worker of race R with productivity s and asset holdings a, working in an np firm, chooses consumption c and future savings a' to maximize their lifetime discounted 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 race-specific probability of extreme wealth shock ϵ_R and the idiosyncratic productivity shock s. The expectation over the wealth shock is denoted by E_{ϵ_R}, and it expands to

$$\mathrm{E}_{\epsilon_R} \hat{W}(R, s, a') = (1-\epsilon_R)\hat{W}(R, s, a') + \epsilon_R \hat{W}(R, s, 0) \tag{3}$$

where $\hat{W}(R, s, a')$ is the expected value over the future realizations of idiosyncratic productivity shock

$$\hat{W}(R, s, a') = \sum_{s'} \pi_{ss'} [\lambda_{np} U^I_{np}(R, s', a') + (1-\lambda_{np}) W_{np}(R, s', a')] \tag{4}$$

Additionally, the employed worker may receive a job destruction shock, specific to np firms, and become unemployed with probability λ_{np}, and continue to stay employed with probability $1-\lambda_{np}$. If unemployed, the worker is eligible to receive unemployment benefits and earns a value of U^I_{np}.

2.4.2 Employed with p firm

Prejudiced firms p hire only white workers. 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 next period. The rest of the problem is similar to the previous case and is given by

$$\begin{aligned} W_p(\mu; wh, s, a) = \max_{c,a'>0} \Big\{ u(c) + \beta E_{\epsilon_{wh}} \sum_{s'} \pi_{ss'} [\quad & \underbrace{\lambda_p U_p^I(\mu'; wh, s', a')}_{\text{expected unemployment value}} \\ & + \underbrace{(1-\lambda_p) W_p(\mu'; wh, s', a')}_{\text{expected continuing employed value}} \ ] \Big\} \end{aligned} \tag{5}$$

s.t.

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

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 in an 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.

Black worker from a np firm

$$\begin{aligned} U_{np}^I(\mu; bl, s, a) = \max_{c,a'>0} \Big\{ u(c) + \beta E_{\epsilon_{bl}} \sum_{s'} \pi_{ss'} \Big[& \underbrace{f(\theta_{np}) W_{np}(\mu'; bl, s', a')}_{\text{value of matching with a np job}} \\ & + \underbrace{(1-f(\theta_{np}))[P_e U_{np}^I(\mu'; bl, s', a') + (1-P_e) U^N(\mu'; bl, s', a')]}_{\text{value of continuing unemployed}} \Big] \Big\} \end{aligned} \tag{6}$$

s.t.

$$c + a' = (1-\tau) b_{np}(bl, s, a) + (1+r)a + d$$

An unemployed black worker eligible for benefits receives unemployment insurance, $b_{np}(bl, s, a)$, and finds a job with probability $f(\theta_{np})$. If the worker doesn't get matched, they continue to receive unemployment benefits with probability P_e and lose their eligibility with probability $1 - P_e$.

White worker from a np firm

$$
\begin{aligned}
U^I_{np}(\mu; wh, s, a) = \max_{c, a' > 0} \Big\{ u(c) + \beta E_{\epsilon_{wh}} \sum_{s'} \pi_{ss'} \Big[& \underbrace{(1 - f(\theta_{np}))f(\theta_p) W_p(\mu'; wh, s', a')}_{\text{value of matching with a p sector job only}} \\
& + \underbrace{f(\theta_{np})(1 - f(\theta_p)) W_{np}(\mu'; wh, s', a')}_{\text{value of matching with a np sector job only}} \\
& + \underbrace{f(\theta_{np}) f(\theta_p) \max\{W_p(\mu'; wh, s', a'), W_{np}(\mu'; wh, s', a')\}}_{\text{value of matching with both p and np jobs}} \\
& + \underbrace{(1 - f(\theta_p))(1 - f(\theta_{np}))}_{\text{not matching with any job}} \Big[\underbrace{P_e U^I_{np}(\mu'; wh, s', a')}_{\text{value of continuing UI}} + \underbrace{(1 - P_e) U^N(\mu'; wh, s', a')}_{\text{value of losing UI}} \Big] \Big] \Big\}
\end{aligned}
$$

s.t.

$$
c + a' = (1 - \tau) b_{np}(wh, s, a) + (1 + r)a + d. \tag{7}
$$

Unemployed white workers are recruited by both p and np firms. An unemployed white worker receives a job offer from a p firm with probability $(1 - f(\theta_{np}))f(\theta_p)$, an offer from an np firm with probability $f(\theta_{np})(1 - f(\theta_p))$, and receive both offers together with probability $f(\theta_{np})f(\theta_p)$. The white worker will remain unemployed if they don't receive any offers (with probability $(1 - f(\theta_p))(1 - f(\theta_{np}))$) and continue to receive unemployment benefits with probability P_e. In the event that the worker receives both p and np offers, they will choose the job that gives them higher lifetime utility.

White worker from a p firm

$$
\begin{aligned}
U_p^I(\mu; wh, s, a) = \max_{c,a'>0} \Big\{ u(c) + \beta E_{\epsilon_{wh}} \sum_{s'} \pi_{ss'} \Big[& \underbrace{(1 - f(\theta_{np}))f(\theta_p)W_p(\mu'; wh, s', a')}_{\text{value of matching with a p sector job only}} \\
& + \underbrace{f(\theta_{np})(1 - f(\theta_p))W_{np}(\mu'; wh, s', a')}_{\text{value of matching with a np sector job only}} \\
& + \underbrace{f(\theta_{np})f(\theta_p)\max\{W_p(\mu'; wh, s', a'), W_{np}(\mu'; wh, s', a')\}}_{\text{value of matching with both p and np jobs}} \\
& + \underbrace{(1 - f(\theta_p))(1 - f(\theta_{np}))}_{\text{not matching with any job}} \Big[\underbrace{P_e U_p^I(\mu'; wh, s', a')}_{\text{value of continuing UI}} + \underbrace{(1 - P_e)U^N(\mu'; wh, s', a')}_{\text{value of losing UI}} \Big] \Big] \Big\}
\end{aligned}
$$

s.t.

$$
c + a' = (1 - \tau)b_p(wh, s, a) + (1 + r)a + d \tag{8}
$$

The problem faced by a white worker who last worked with a p firm is identical to the previous case, except they earn $b_p(wh, s, a)$ as their unemployment benefit.

2.4.4 Unemployed and ineligible workers

Ineligible workers no longer receive any unemployment benefits. Their income comes only from their past savings and dividends, and doesn't depend on their previous employment.

Black worker

$$
\begin{aligned}
U^N(\mu; bl, s, a) = \max_{c,a'>0} \Big\{ u(c) + \beta E_{\epsilon_{bl}} \sum_{s'} \pi_{ss'} \Big[& \underbrace{f(\theta_{np})W_{np}(\mu'; bl, s', a')}_{\text{value of matching with a np job}} \\
& + \underbrace{(1 - f(\theta_{np}))U^N(\mu'; bl, s', a')}_{\text{value of staying unemployed}} \Big] \Big\}
\end{aligned} \tag{9}
$$

s.t.

$$
c + a' = (1 + r)a + d
$$

White worker

$$
\begin{aligned}
U^N(\mu; wh, s, a) = \max_{c,a'>0} \Big\{ u(c) + \beta E_{\epsilon_{wh}} \sum_{s'} \pi_{ss'} \Big[& \underbrace{(1 - f(\theta_{np}))f(\theta_p)W_p(\mu'; wh, s', a')}_{\text{value of matching with a p sector job only}} \\
& + \underbrace{f(\theta_{np})(1 - f(\theta_p))W_{np}(\mu'; wh, s', a')}_{\text{value of matching with a np sector job only}} \\
& + \underbrace{f(\theta_p)f(\theta_{np}) \max\{W_p(\mu'; wh, s', a'), W_{np}(\mu'; wh, s', a')\}}_{\text{value of matching with both np and p sector jobs}} \\
& + \underbrace{(1 - f(\theta_p))(1 - f(\theta_{np}))U^N(\mu'; wh, s', a')}_{\text{value of continuing unemployed}} \Big] \Big\}
\end{aligned} \tag{10}
$$

s.t.

$$c + a' = (1 + r)a + d$$

Thus, the problem faced by an ineligible worker is analogous to an eligible worker, except that they don't receive unemployment benefits.

2.5 Firms

There are a large number of p and np firms that can post vacancies as long as they pay the vacancy posting costs. The 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 get matched with an unemployed worker with probability $q(\theta_{np})$.

The value of a vacant np firm, V_{np}, is

$$
\begin{aligned}
V_{np} = -\kappa_{np} + \Big(\frac{q(\theta_{np})}{1+r}\Big) \int_a \Big\{ \sum_{s'} \pi_{ss'} \Big[& \underbrace{J_{np}(bl, s', a') \frac{\phi_u(bl, s, a)}{u}}_{\text{value of matching with a type (s,a) black worker}} \Big] \\
+ \sum_{s'} \pi_{ss'} \Big[& \underbrace{\mathbb{1}_{\{W_{np}(\mu'; wh, s', a') \geq W_p(\mu'; wh, s', a')\}}}_{\text{np provides higher value than a p firm}} \Big(\underbrace{J_{np}(wh, s', a') \frac{\phi_u(wh, s, a)}{u}}_{\text{value of matching with (s,a) white worker}} \Big) \\
+ & \underbrace{\mathbb{1}_{\{W_{np}(\mu'; wh, s', a') < W_p(\mu'; wh, s', a')\}}}_{\text{p provides higher value than a np firm}} \Big(\underbrace{J_{np}(wh, s', a') \frac{\phi_u(wh, s, a)}{u} \Big)(1 - f(\theta_p))}_{\text{value of matching (s,a) worker without competing p offer}} \Big] \Big\} da,
\end{aligned}
\tag{11}
$$

where $J_{np}(R, s, a)$ is the value of a producing firm matched with a worker of race R, productivity s, and asset 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 population of unemployed black workers with productivity s and asset a, while $\phi_u(wh, s, a)$ is the corresponding population 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, and these reflect the probabilities that a vacant np firm gets matched with a black and a white unemployed worker respectively. Since the white unemployed workers can potentially receive a competing offer from a p firm, the white worker will accept the np match and begin producing only if it gives them a higher value, or if the worker did not receive a p firm offer.

2.5.2 Vacant p firm

Vacant p firms pay a posting cost of κ_p and restrict their search only among unemployed white workers. The probability of matching with a white unemployed worker is $q(\theta_p)$, and

the value of maintaining a p vacancy, V_p, is

$$V_p = -\kappa_p + \Big(\frac{q(\theta_p)}{1+r}\Big)\sum_{s'}\pi_{ss'}\int_a \Big[\underbrace{\mathbb{1}_{\{W_p(\mu';wh,s',a')>W_{np}(\mu';wh,s',a')\}}\Big(J_p(wh,s',a')\frac{\phi_u(wh,s,a)}{u_{wh}}\Big)}_{\text{value of matching with (s,a) white worker, having higher value than np firm}}$$
$$+\underbrace{\mathbb{1}_{\{W_p(\mu';wh,s',a')\leq W_{np}(\mu';wh,s',a')\}}\Big(J_p(wh,s',a')\frac{\phi_u(wh,s,a)}{u_{wh}}\Big)(1-f(\theta_{np}))}_{\text{value of matching with (s,a) white worker without competing np offer}}\Big]da \tag{12}$$

Since the vacant p firm searches only among white workers, the probability of matching with an unemployed white worker having productivity s and asset a is given by $\phi_u(wh,s,a)/u_{wh}$. Similar to the case of np firms, the white worker accepts the p match only if the p offer is more favorable, or if they don't receive a competing np offer.

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

Upon a successful match with a worker of state (R,s,a), the filled np firm rents capital in order to start production. The value of a producing np firm is

$$J_{np}(\mu;R,s,a) = \max_k\Big\{j(\mu;R,s,a) + \Big(\frac{1-\lambda^{np}}{1+r}\Big)E_{\epsilon_R}\sum_{s'}\pi_{ss'}J_{np}(\mu';R,s',a')\Big\}$$
$$\text{where} \tag{13}$$
$$j(\mu;R,s,a) = sf(k) - (r+\delta)k - \omega_{np}(\mu;R,s,a).$$

The matched firm produces $sf(k)$ units of output, pays the rental and the depreciation cost of capital, $(r+\delta)k$, and the wage cost, $\omega_{np}(\mu;R,s,a)$. The firm discounts their future profits using the interest rate adjusted for the job destruction rate λ_{np}.

2.6 Producing p firm

Similar to a producing np firm, producing p firm hires capital and discounts future profits after accounting for the job destruction rate λ_p.

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

where

$$j(\mu; wh, s, a) = sf(k) - (r+\delta)k - \omega_p(\mu; wh, s, a). \tag{14}$$

2.7 Wage bargaining

Matched worker-firm pairs bargain for their wages period-by-period. The worker's bargaining power ξ_R depends on the race of the individual, and the firm's bargaining power is $1-\xi_R$. The resulting wage for p and np matches are given by

$$\omega_{np}(\mu; R, s, a) = \arg\max_{\omega} \Big(W_{np}(\mu; R, s, a) - U^I_{np}(\mu; R, s, a) \Big)^{\xi_R} J_{np}(\mu; Ra, s, a)^{1-\xi_R} \tag{15}$$

$$\omega_p(\mu; wh, s, a) = \arg\max_{\omega} (W_p(\mu; wh, s, a) - U^I_p(\mu; wh, s, a))^{\xi_{wh}} J_p(\mu; wh, s, a)^{1-\xi_{wh}} \tag{16}$$

We define the stationary equilibrium in Appendix A.

3 Calibration

A period in the model represents a quarter. We calibrate the baseline 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

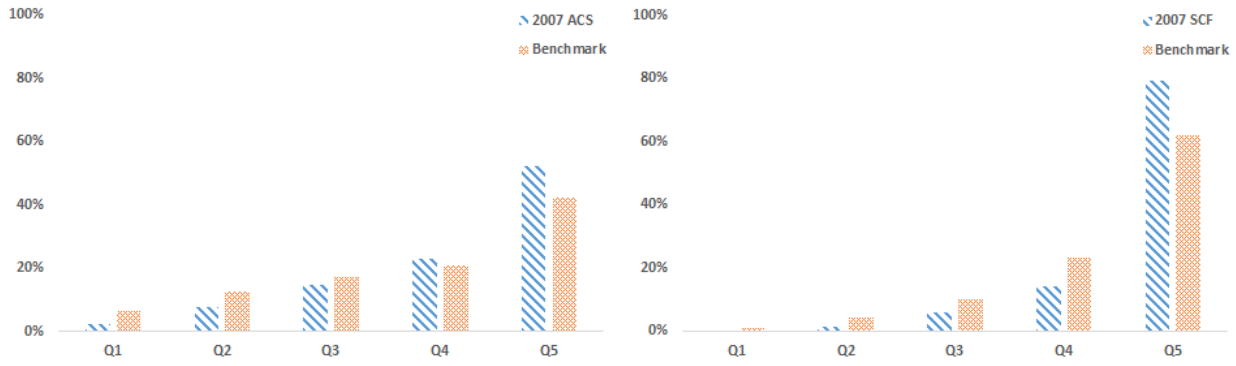
maximum payout χ to be 0.8433, which amounts to 48% of the median wage in the model. The eligibility probability P_e is chosen to be 0.5385 to generate an average unemployment benefit duration of 26 weeks, as in Mitman and Rabinovich (2015).

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 separation rates λ_{np} and λ_p to match the 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 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.

[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.

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 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,

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.

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 declining 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 cost and job destruction rates. 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 becomes unprofitable. The value of κ_p at which p firms exit is 9.24, compared to the benchmark value of 4.26. Meanwhile, non-discriminatory (np) firms become nearly the sole employers in the economy. The grey dotted lines in Figure 2 illustrate a counterfactual steady state where we entirely remove p firms from the benchmark model. Thus, increasing

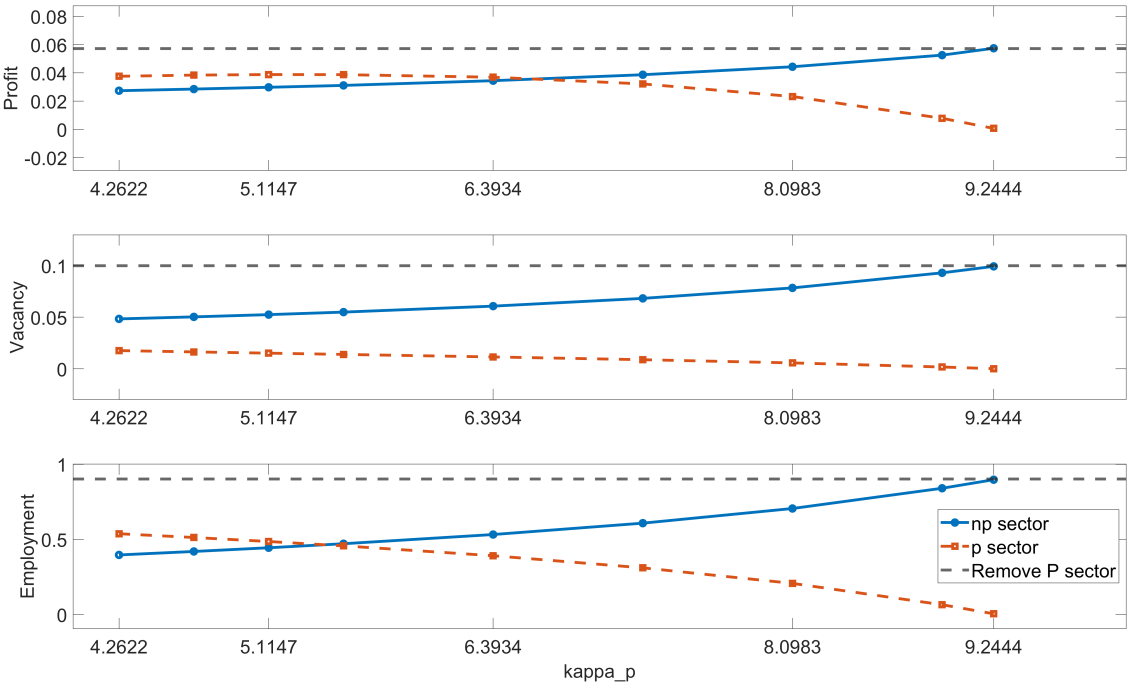


Figure 2: Penalizing Discrimination

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 grey dotted line depicts the limit where no p firm exists.

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. Specifically, all firms in the counterfactual model provide equal hiring opportunities to black and white workers. Additionally, we attach job destruction shocks to workers and have λ_{wh} and λ_{bl} as race-specific job separation rates.[7] Re-assigning the job separation rates allows us to isolate the impact of hiring discrimination from complexities on job destruction. Table 3 presents the comparisons.

[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 λ_{wh} to be 0.038 and 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
Households		
job finding rate - black	0.50	0.62
job finding rate - white	0.66	0.62
job separation rate - black	0.06	0.06
job separation rate - white	0.04	0.04
unemp rate - black	0.12	0.09
unemp rate - white	0.05	0.06
mean wage - black	1.60	1.82
mean wage - white	2.13	2.11
mean wage ratio	0.75	0.86
mean wealth ratio	0.28	0.33
median wealth ratio	0.33	0.44
Firms		
p firm profit	0.04	-
np firm profit	0.03	0.06
p firm vacancy	0.02	-
np firm vacancy	0.05	0.07
p firm employment	0.54	-
np firm employment	0.40	0.94
Labor Market		
p market tightness	0.40	-
np market tightness	0.73	1.12
Aggregate Outcomes		
Y	3.06	3.06
K/Y	10.26	10.25
average wage	2.04	2.05
unemp rate	0.07	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.

The first panel shows the changes in racial employment, wage, and wealth disparities after removing prejudiced hiring. Since there is no p sector in the economy, the job-finding rates are equalized for black and white workers. As we re-assign the job destruction shock, the disparity in the job separation rate remains. This reduces the racial gap in the unemployment rate from 7% to 3%. The counterfactual economy (Column 2) has a black workers' unemployment rate of 9% and white workers with an unemployment rate of 6%. As we remove discriminatory hiring, more non-discriminatory firms with equal employment opportunities enter the market and retain higher profits. Black workers receive more job opportunities and can bargain for a higher wage rate. 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 wage ratio increases from 75% in benchmark to 86%. We conclude that removing discriminatory hiring closes 44% of the average wage gap between black and white workers. Additionally, removing discriminatory hiring closes the wealth gap, with the mean wealth ratio moving from 0.28 to 0.33 and the median wealth ratio increasing from 0.33 to 0.44. We infer that discriminatory hiring explains about 7% mean wealth gap and 16% median wealth gap. The remaining wage gap comes 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 refer to the one-sector economy without discriminatory hiring as np firms, though it differs from the benchmark np firms in constructing job destruction shock. Without discriminatory firms, np firms' profit doubles, vacancy posting increases, and their employment level increases from 0.4 to 0.94.

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 1.12 in the equilibrium without p firms. The ensuing market tightness is higher than the benchmark aggregate market tightness of 1.

[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.

The last panel of Table 3 describes the aggregate outcomes. With more *np* firms entering, the aggregate output stays relatively the same. 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%.

Our results show that the presence of discriminatory firms can explain sizable fractions of income and wealth inequality. Penalizing prejudiced firms primarily improves the employment 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. In order 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 1.17% increase in average welfare. Once we eliminate discriminatory hiring, black workers have an average welfare increase of 10.94%. This is driven by the increase in non-discriminatory firms posting vacancies and their profit hike.

[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.

On the other hand, white workers encounter an average welfare loss of 1.14%. This is because of their decrease in wage rate and increase in 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 is similar across productivity for white workers, the largest loss is for the highest productive workers at 1.19%. In comparison, the most productive black workers have the highest welfare gain at 11.49%.

Table 4: Heterogeneous welfare change

Average welfare gain (%)	Eliminate p firms	
Overall	1.17	
	Black	White
Average	10.94	-1.14
	by productivity	
Low	10.31	-1.07
Mid	10.98	-1.14
High	11.49	-1.19
	by wealth	
Low 20%	10.98	-1.13
40-60%	10.94	-1.17
Top 20%	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 and adjust the job destruction shock to be race-specific. 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 lowest-quintile black workers the most – an average welfare gain of 10.98%. The most considerable reduction in welfare (1.17%) happens for the mid-quintile white workers.

5 Business cycle dynamics

In this section, we first document the racial disparities over the business cycle. Then, we introduce aggregate uncertainty in our baseline 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.

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. Cyclicality is measured as the correlation between the unemployment rate gap and real GDP, while volatility is measured by the standard deviations. We find that the racial unemployment rate gap is countercyclical, widening during recessions and narrowing during expansions.

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

	Cyclicality	Volatility
	Unemployment rate	
Black-White gap	-0.6255	0.1116
	Average wage	
Black	2.6041	0.0166
White	1.2729	0.0137

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 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). 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 standard deviation 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. Even though the average wage is not particularly volatile, black workers' average wage is more volatile (0.0166) than white workers (0.0137).

5.2 Augmented model with aggregate shocks

We introduce an aggregate total factor productivity (TFP) shock z to the baseline 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 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

[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:

$$\Delta \log w_{it} = \alpha + \beta \Delta \log Y_t + \gamma x_{it} + \nu_t + \upsilon_s + \epsilon_{it} \tag{17}$$

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.

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 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	0.1116	0.0059
	Average wage			
Black	2.6041	1.0749	0.0166	0.0159
White	1.2729	0.9984	0.0137	0.0151

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 presents the comparison of data and model moments on unemployment and wages. Similar to standard search models, the stochastic dynamics of our model is under the influence of the Shimer Puzzle (Shimer, 2005). The augmented benchmark model generates similar cyclicality in unemployment rate gap as data, but a much less volatility in unemployment rate gap. In terms of the average wage, the model has lower cyclicality for both black and white workers and a less pronounced differences in volatility. But qualitatively, we are able to have a higher wage cyclicality and volatility for black workers.

[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.

5.3 Impact of hiring discrimination over business cycle

We compare the benchmark dynamics with the counterfactual model without p firms in Table 7. This allows us to examine the role of discriminatory hiring in creating racial disparities over the business cycle.[12]

The counterfactual equilibrium with no p firms does not generate an empirically valid cyclical racial unemployment gaps, both the cyclicality and volatility largely reduce. The racial difference in the cyclicality of the average wage also reduces, though the difference in wage volatility stays relatively unchanged.

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

	Cyclicality		Volatility	
	Baseline	No p firms	Baseline	No p firms
		Unemployment rate		
Black-White gap	-0.6731	-0.5201	0.0059	0.0022
		Average wage		
Black	1.0749	1.0189	0.0159	0.0201
White	0.9984	0.9819	0.0151	0.0194
		Wealth ratio		
Wealth ratio	0.2028	0.2146	0.1611	0.1502
		Consumption ratio		
Consumption ratio	0.9717	0.9702	0.1861	0.1720

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.

We further examine the behaviors in the cyclical properties of average wealth ratio and average consumption ratio. Other than the cyclicality of the average wealth ratio, the cyclical properties of all other dimensions reduce after removing the discriminatory hiring.

In summary, with the presence of p firms, black workers are relatively more affected during recessions compared to white workers, with a higher increase in their unemployment rate and a more considerable decline in their wages, consumption, and wealth. This corresponds to Cajner et al. (2017) that demographic differentials cannot fully explain the observed

[12]Consistent with Table 3, we adjust the one sector economy with race-specific job destruction shocks.

differences in racial disparities over the business cycles.

5.4 Welfare disparities in business cycles

Lastly, we examine the welfare implications of the reduced cyclical properties once 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	0.68	
	Black	White
Average	0.46	0.73
by productivity		
Low	0.44	0.77
Mid	0.46	0.72
High	0.50	0.69
by wealth		
Low 20%	0.44	0.73
40-60%	0.49	0.73
Top 20%	0.51	0.71

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 0.68% welfare increase after removing prejudiced firms. This is much less than the welfare change in the steady state in Table 4, primarily because all workers experience an increase in wage rate volatility that somewhat counters the changes in other dimensions. Moreover, all workers have a modicum of increase in average welfare, compared to the minor decrease in white workers' welfare in the steady state. This is because of the reduction in consumption volatility for all workers in Table 7. On average,

black workers gain 0.46% average welfare compared to white workers gaining 0.73%. High-productive black workers gain the most from removing p firms (0.5%), while low-productive white workers gain the most (0.77%). Top 20% wealth black workers gain the most (0.51% on average), compared to bottom wealth white workers gaining the most (0.73%).

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 an increase 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 $\Big\{W_{np}(\mu; R, s, a), W_p(\mu; wh, s, a), U^I_{np}(\mu; R, s, a), U^I_p(\mu; wh, s, a), U^N(\mu; R, s, a)\Big\}$, and firms $\Big\{V_{np},\, V_p,\, J_{np}(\mu; R, s, a),\, J_p(\mu; wh, s, a)\Big\}$
2. Corresponding asset policy functions of workers $\Big\{g_{np}(\mu; R, s, a), g_p(\mu; wh, s, a), g^I_{np}(\mu; R, s, a), g^I_p(\mu; wh, s, a), g^N(\mu; R, s, a)\Big\}$, along with the capital choice of producing firms $\Big\{k_{np}(\mu; R, s, a), k_p(\mu; wh, s, a)\Big\}$ and vacancy choice of vacant firms $\Big\{v_{np},\, v_p\Big\}$
3. Wages $\Big\{\omega_{np}(\mu; R, s, a),\, \omega_p(\mu; wh, s, a)\Big\}$
4. Aggregate interest rate and labor market tightness $\Big\{r,\, \theta_{np},\, \theta_p\Big\}$
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. $\Big\{W_{np}(\mu; R, s, a), W_p(\mu; wh, s, a), U^I_{np}(\mu; R, s, a), U^I_p(\mu; wh, s, a), U^N(\mu; R, s, a)\Big\}$ are the solutions to the worker's optimization problems (equations 2, 5, 6, 7, 8, 9, and 10), and $\Big\{g_{np}(\mu; R, s, a), g_p(\mu; wh, s, a), g^I_{np}(\mu; R, s, a), g^I_p(\mu; wh, s, a), g^N(\mu; R, s, a)\Big\}$ are the associated optimal decision rules for asset choice.
2. $\Big\{J_{np}(\mu; R, s, a),\ J_p(\mu; wh, s, a)\Big\}$ are the solutions to the producing firm's problems (equations 13 and 14), and the corresponding capital choice is given by $\Big\{k_{np}(\mu; R, s, a), k_p(\mu; wh, s, a)\Big\}$.
3. Free entry of vacant firms, i.e., $V_{np} = 0$ and $V_p = 0$ determines the number of vacancies $\Big\{v_{np},\, v_p\Big\}$, and hence labor market tightness $\Big\{\theta_{np},\, \theta_p\Big\}$.

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

5. Wages $\left\{\omega_{np}(\mu; R, s, a),\ \omega_p(\mu; wh, s, a)\right\}$ 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.

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

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

Appendix B Comparing aggregate implications 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. Overall, removing non-market disparities raises black workers' welfare and aggregate outputs. Equalizing black workers' bargaining power to white workers directly raises their bargained wage outcomes. However, non-prejudiced firms retain less profit, hence posting fewer vacancies. On the net,

it only has a modicum impact on black workers' welfare. The reduction of non-prejudiced sector vacancy posting spills over to welfare reduction for white workers.

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

Moments	Benchmark	$\xi_{bl} = \xi_{wh}$	$\epsilon_{bl} = \epsilon_{wh}$
Labor Market			
np market tightness	0.73	0.69	0.78
p market tightness	0.40	0.27	0.26
job finding rate (Black)	0.50	0.46	0.48
job finding rate (White)	0.66	0.64	0.65
unemp rate (Black)	0.12	0.12	0.12
unemp rate (White)	0.05	0.05	0.05
Income			
mean wage ratio	0.75	0.82	0.78
average wage	2.04	2.05	2.06
Wealth			
mean wealth ratio	0.28	0.21	0.76
median wealth ratio	0.33	0.27	0.82
share of zero wealth (Black)	0.18	0.18	0.07
share of zero wealth (White)	0.07	0.07	0.07
Aggregate Outcomes			
Y	3.06	3.05	3.08
K/Y	10.26	10.25	10.45
unemp rate (%)	6.60	6.78	6.64
Average welfare gain (%)			
Average		0.66	1.10
black		6.27	8.69
white		-0.66	-0.69

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

To equalize racial wealth shocks, 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 wealth in self-insuring against uncertain negative outcomes (Nakajima, 2012). Higher personal wealth gives black workers higher reservation value when bargaining with firms. Effectively, black workers can bargain for higher wage outcomes. Similar to assigning a higher bargaining power directly, the more

favorable wealth accumulation of black workers also spills over to the firm's unwillingness to post for more vacancies. Indirectly, it reduces white worker's job outcomes and welfare.

Appendix C Impulse responses

Figure C.1 plots the response of labor market, wealth, and consumption outcomes of both black and white workers after an unanticipated expansionary shock. For the impulse response function to represent the numerical derivative, the magnitude of the MIT shock should be small. We provide a 1% positive shock to z at the initial period, i.e., $\epsilon_z = 0.01$, and let the TFP return to the steady state deterministically. We compare the benchmark model response to the counterfactual model without p firms to study the impact of hiring discrimination over the business cycle. Overall, our models generate countercyclical unemployment rate and procyclical wage, wealth, and consumption movements. As is standard in the literature on dual labor markets, the single market model (without p firm) reverts to the steady state faster than the dual market model (benchmark) (e.g. Horvath and Yang, 2022). However, in the benchmark model with discriminatory firms, black workers experience more pronounced changes in unemployment rates and consumption in response to an expansionary shock compared to white workers. While average wages and wealth show little difference between models with and without discriminatory firms, the black-white average wage and wealth ratios are more procyclical in the benchmark model with discriminatory firms.

Figure C.2 presents the impulse responses 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.

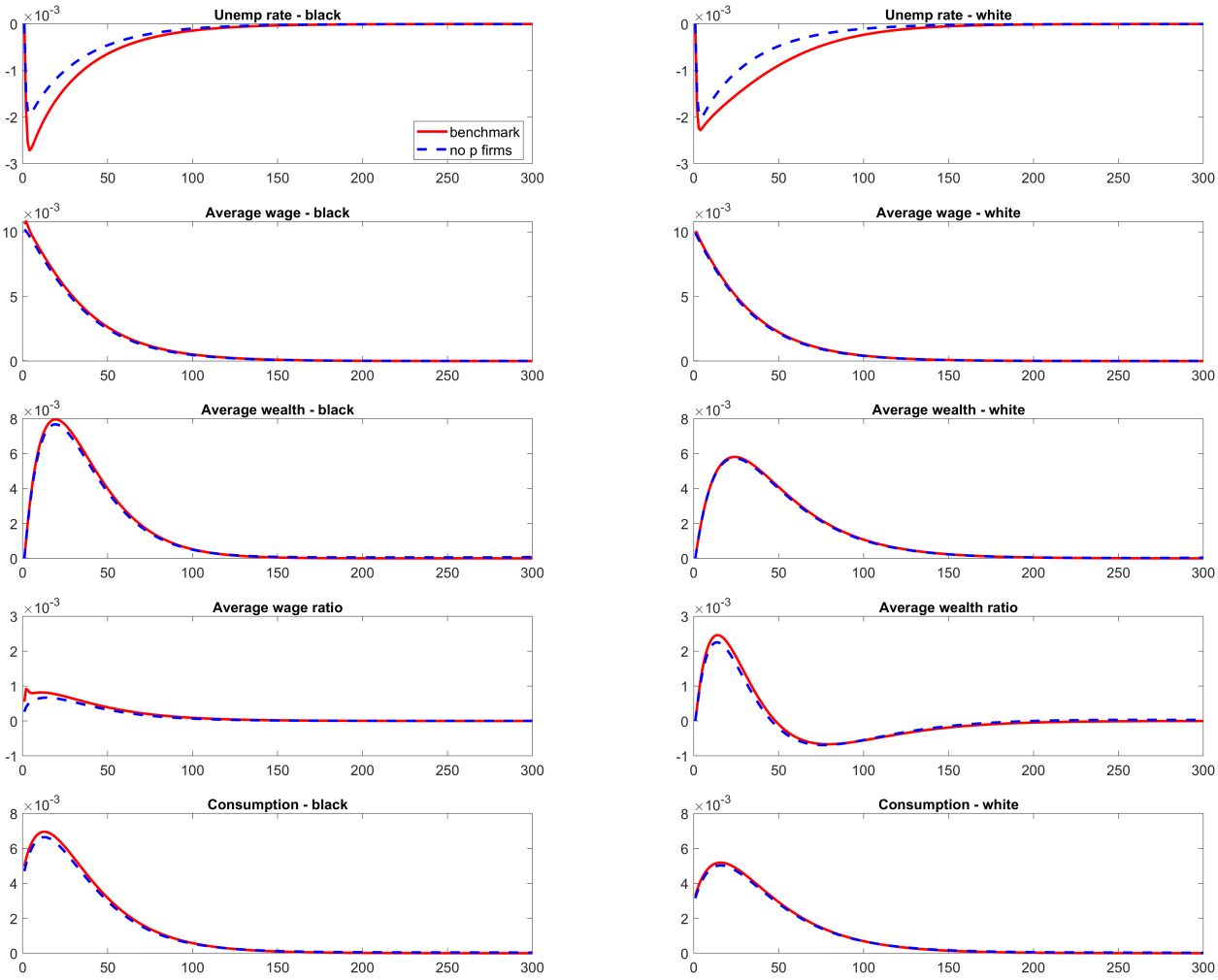


Figure C.1: Impulse responses

Note: This figure plots the impulse response functions of unemployment rates, average wage, average wealth, 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.

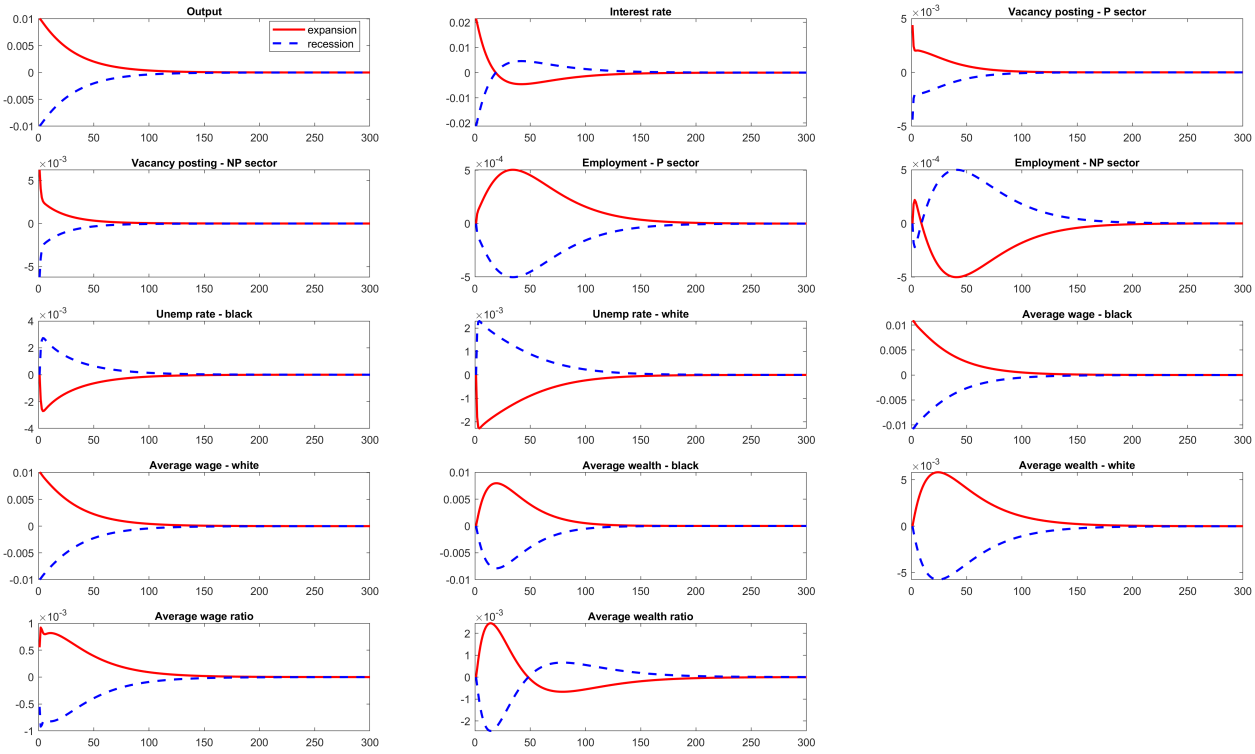


Figure C.2: Comparing impulse responses

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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