Neighborhood Segregation and Endogenous Racial Bias *

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Abstract

The paper explores the role of residential segregation in sustaining racial economic disparities in the U.S. We show that income gaps between Black and white Americans are more pronounced in regions with higher residential segregation. To understand this finding, we develop a general equilibrium overlapping generations model with residential choice and local spillovers, where white and black agents are identical except that black agents start with an initial income distribution that is first order stochastically dominated by that of white agents. Moreover, when white agents infer the ability distribution from the observed income distribution, they do not take into consideration that agents were exposed to different local spillovers when growing up. Given the initial conditions, this generate an endogenous racial bias that is due to residential segregation by income. We show that economies with higher degree of residential segregation by income features larger racial bias and higher residential segregation by race. Moreover, the model generates multiple equilibria that depends on the initial conditions. We finally show that a simple reparative policies could shift the economy toward a more equitable equilibrium, reducing racial economic gaps.

Keywords: Income inequality, Residential segregation, Racial bias, Local externalities
JEL Classification: E24, I2, O15, R2

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1 Introduction

Racial disparities in economic outcomes have been a persistent feature of the U.S. economy, with significant and long-standing gaps in income, wealth, and educational attainment between Black and white Americans. We show that these gaps are particularly pronounced in regions with high levels of residential segregation, suggesting a potential relationship between neighborhood composition and racial discrimination. Understanding the role of segregation in shaping these disparities is crucial for both economic theory and policymaking. This paper examines whether residential segregation has contributed to the persistence and amplification of racial economic gaps and explores the mechanisms through which this process unfolds.

We start by documenting a novel linkage between racial disparities and residential segregation by income. In particular, using geo-coded Census data, we show that the earning gap between white and black Americans is more severe in areas with higher levels of residential segregation, and this is more pronounced in the last few decades when residential segregation by income has increased. Moreover, we show that the probability of moving out of poverty, measured as the inverse of the probability of remaining in the lowest quartile of the income distribution when the parents are in the lowest quartile, is lower for the metros with higher residential segregation by income. These facts raise the question of whether segregation itself is a driver of racial disparity.

To analyze this issue, we develop a general equilibrium overlapping generations model with both white and black agents, with residential choice and local spillovers, where residential segregation and racial bias emerge endogenously. There are two neighborhoods, A and B, and neighborhood exposure affects children's income. The local spillover depends on the average parental income and on the average ability of the children growing up in the neighborhood. This general formulation allows us to capture several forces behind the local externalities: quality of public schools through local taxation, networks, social norms, peer effects, learning from neighbors' experience, and so forth.

We first consider a benchmark model, where white and black agents are identical, except for their initial income distribution. In particular, we assume that the initial income distribution of the black agents is first-order stochastic dominated by the initial income distribution of the white agents. The presence of local spillovers generate residential segregation by income in equilibrium. Let A be the neighborhood with higher spillover. Given that the black parents are initially poorer, they are going to be more concentrated in neighborhood B, and hence being exposed to the lower spillover. This can make the income gap between

white and black persistent, although it may disappear in the steady state.

We then consider a "model with racial bias," where we introduce a behavioral assumption: the white agents do not take into account that parents have been exposed to different local spillovers growing up, when they infer their ability from the observed income. Given that black agents are initially more concentrated in neighborhood B, when white agents observe lower average income for black agents, they infer that black agents have lower average ability. This is what we refer to as endogenous racial bias. This is going to affect their beliefs about the local spillovers in the two neighborhoods and distort their residential choice. In particular, white agents will be willing to pay higher rents to live in neighborhood A relative to the effective benefit of growing up there. This will make the racial bias to persists even in the absence of fundamental differences in ability distributions and even when it disappears in the benchmark model with rational expectations.

Our model features multiple equilibria. This suggests that there might be simple reparation policies that can help switching the economy from a bad to a good equilibrium, reducing economic disparities and the racial bias.

2 Empirical Evidence

In this section we document the recent increase in the earnings gap between black and white men. We use decennial Census data and focus on men 25-54. In Figure 1 we plot the gap in earnings between black and white men from 1950 and 2010, both for all men and restricting the sample to those with positive earnings. Two clear facts emerge. First, black men have made substantial progress in terms of earning during the first part of the sample period. However, post 1980, this progress has reverted. Second, the gap in earnings is larger and increasing faster when considering all men, as the fraction of individuals out of the labor force is much larger among blacks. For this group, the gap in earnings in 2010 is larger than it was in 1950. Over the same time period, residential segregation by race in US metros declined. Figure 2 shows the dissimilarity index by race (red line) calculated as the weighted average of the metro level segregation when using the census tract as geographic sub-unit of analysis. However, while residential segregation by race declined, segregation by income increased rapidly (blue line). For this reason, we investigate next the relationship between race earning gap and segregation. Figure 3 shows the split of the overall race earning up between two sub-samples of the population: men living in metros highly segregated by race (as measured by the dissimilarity index) and men living in low segregated ones. Figure 4 shows the same split

using income segregation to split the sample. Both figures show that the large increase in the race earnings up of the last 30 years is mostly driven by the evolution of the earnings in highly segregated metros. In particular, while in 1980 there is no or small differences among earning gap in low and highly segregated metros, the differences had strongly increased over the last 30 years. Figure 5 and 6 show the scatter plot of the earning gap across metros as a function of their level of segregation as captured by the dissimilarity index. Not only metros with more residential segregation are characterized by larger earning gaps between black and white men, buy also intergenerational mobility is lower. Figure 7 shows that black men born in the bottom quintile of the income distribution have the lowest probability to move up. Especially in highly segregated cities.

Figure 1: Black White Earnings Gap

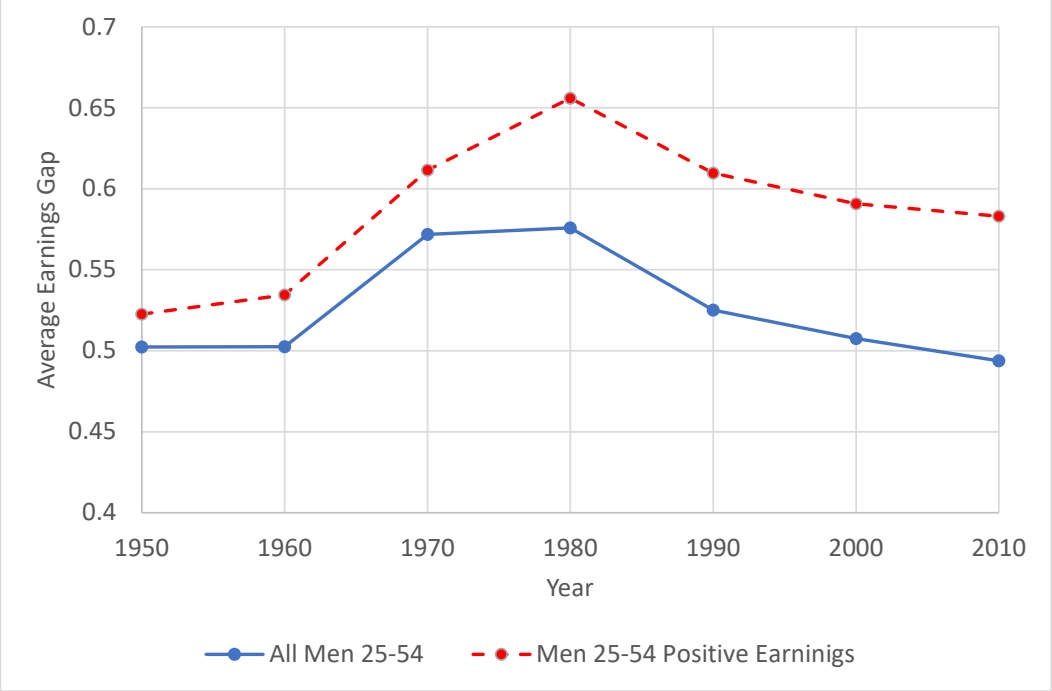


Figure 2: Race and Income Segregation

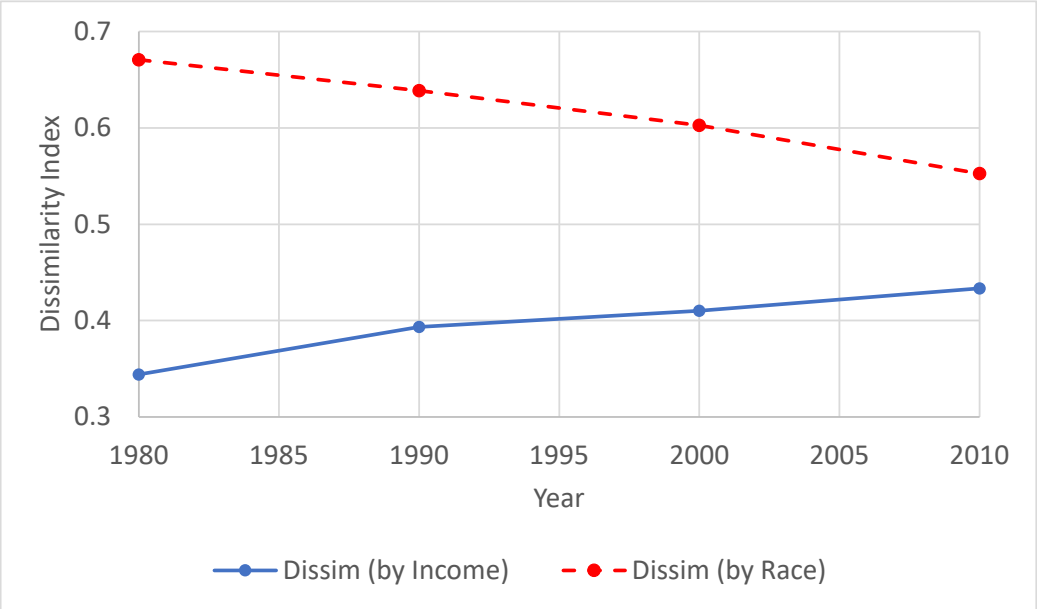


Figure 3: Earnings Gap by Race Segregation

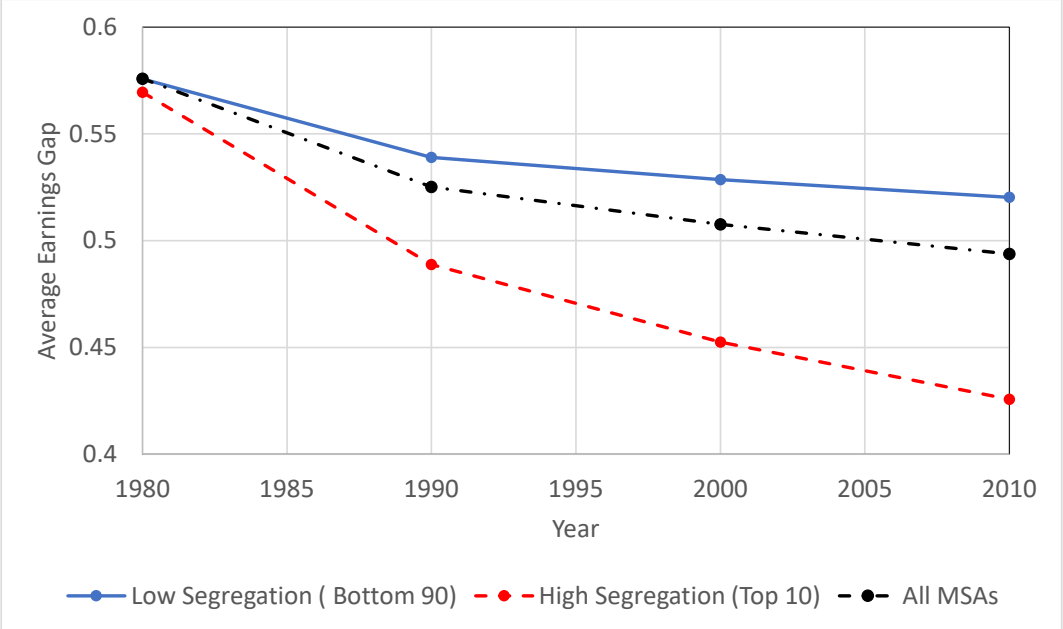


Figure 4: Earnings Gap by Income Segregation

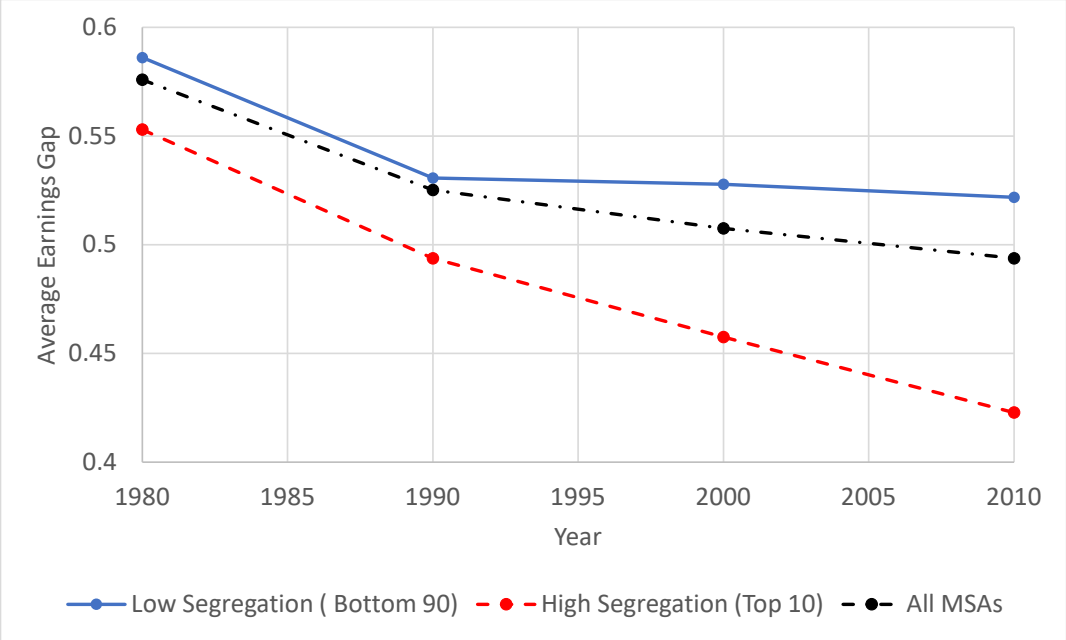
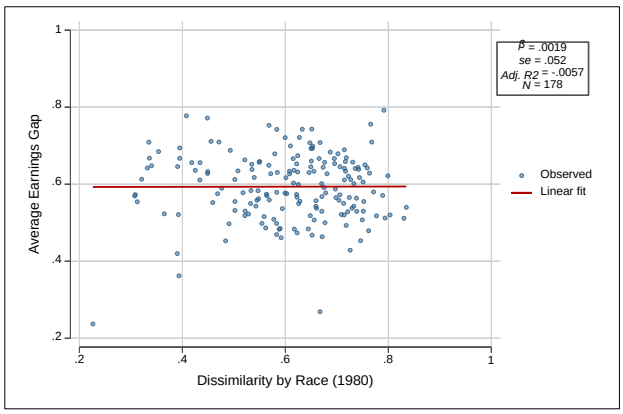
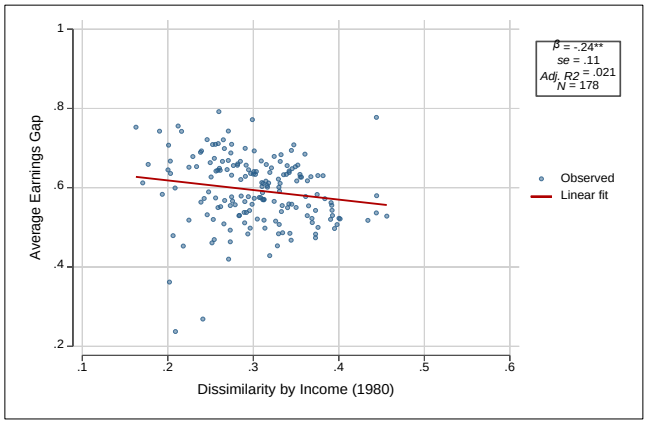


Figure 5: Earnings gap and Segregation 1980



(a) Race Segregation

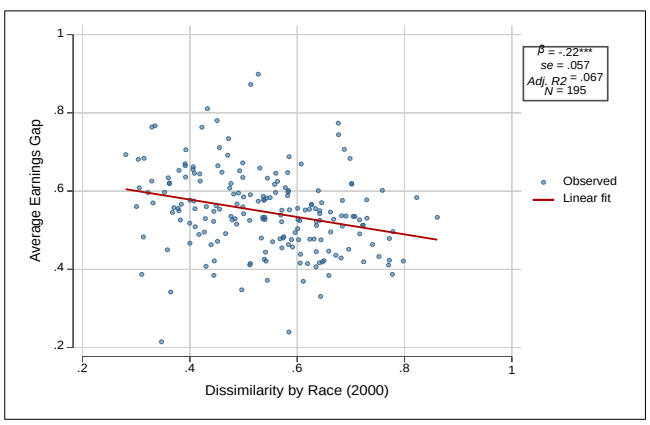


(b) Income Segregation

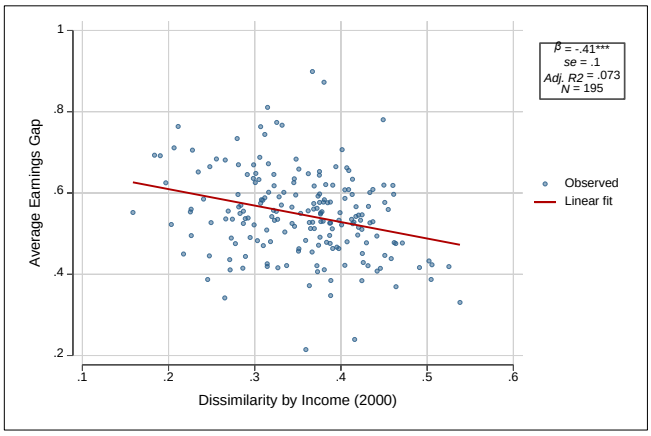
3 Model

The economy is populated by overlapping generations of agents who live for two periods. In the first period, the agent is a child, and in the second period, she is a parent. At each time t there is a continuum

Figure 6: Earnings gap and Segregation 2000

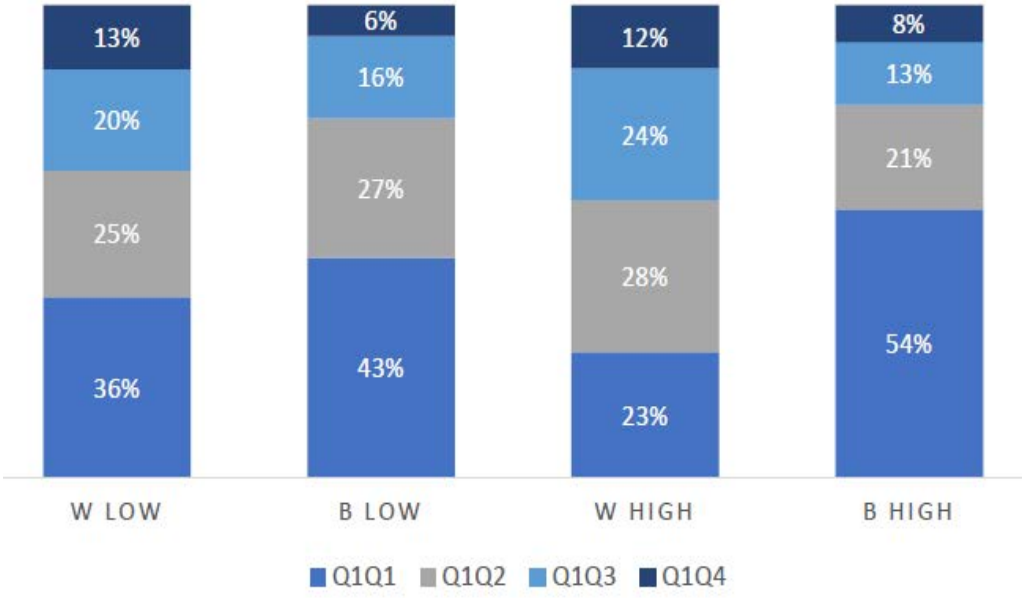


(a) Race Segregation



(b) Income Segregation

Figure 7: Upward Mobility by Race



of measure 1 of parents, of which a fraction μ is black. At each time t, a parent at time is characterized by a triplet $\{y,a,\chi\}$, where $y \in [\underline{y},\bar{y}]$ denotes the parental income, $a \in [\underline{a},\bar{a}]$ the ability of the child, and $\chi \in \{w,b\}$ the parent's race, where $\chi = w$ if the agent is white and $\chi = b$ if she is black.

Let us define $F_t(y,a|\chi)$ the joint distribution of parental income and children ability conditional on the

parent race χ.

On the one hand, we assume that ability is iid with respect to parental income and race, so that the marginal distribution for ability is identical for white and black parents and is the same at each time t, that is,

$$F_{a,t}(a|w) = F_{a,t}(a|b) = G(a),$$

for all $t \geq 0$, where $F_{a,t}(a|\chi)$ denotes the marginal distribution with respect to a at time t, conditional on race χ. We assume that ability is perfectly transmitted across generation, that is, the ability of a child is the same as her parent's ability. This implies that the ability distribution is invariant over time and we denote it as $G(a)$. A parent knows her child's ability, but cannot observe the ability of the other children.

On the other hand, we assume that the initial marginal distribution of income for black parents is first-order stochastically dominated by the marginal distribution of income for white parents, that is,

$$F_{y,0}(y|w) \leq F_{y,0}(y|b),$$

with strict inequality at some y. However, the marginal distribution with respect to income conditional on race, $F_{y,t}(y|\chi)$, evolves endogenously over time, as children's income is affected by the parental residential choice, as we explain below.

There are two neighborhoods, A and B, and the parents live in houses of the same dimension and quality. Let R_{At} and R_{Bt} denote the rents at time t in the two neighborhoods. For simplicity let us assume that neighborhood A has a fixed housing supply H, and that neighborhood B features perfectly elastic housing supply.[1] Moreover, let us normalize the marginal cost of housing construction in neighborhood B to zero. This implies that $R_{Bt} = 0$ for all t, and the only endogenous price is the rent in neighborhood A, $R_A t$.

At each time t parents choose their consumption $c_t(y,a,\chi)$ and the neighborhood where to raise their children $n_t(y,a,\chi)$. Parents care both about their own consumption and about their children's future income.[2] In particular, their preferences are given by $u(c_t(y,a,\chi) + g(y_{t+1}(y,a,\chi))$, where u is a concave

[1] We can easily generalize the model to a more standard housing supply in neighborhood $k \in \{A,B\}$, equal to

$$H_{kt} = \lambda_k R_{kt}^{\phi_k},$$

where ϕ_k represents the housing elasticity in neighborhood k and λ_k a positive scalar. The important assumption for the qualitative results is that there is at least one neighborhood with not fully elastic housing supply.

[2] This assumption is common in this class of models. The assumption that agents cannot save (if not by investing in housing or kids'education) is for simplicity. The assumption that agents cannot borrow is for realism, given that typically people cannot borrow against children's future income. An alternative specification could have parents getting utility directly from their children's consumption, with the introduction of a more general borrowing constraint.

and continuously differentiable utility function, and g is increasing and continuously differentiable, and $y_{t+1}(y,a,\chi)$ is their child's income.

The key difference between the two neighborhoods is given by the presence of local spillovers that affect the future income of children growing up there. We denote the size of the local spillover in neighborhood n at time t by S_{nt}. Together with the local spillover, children's income is affected by their ability, that is,

$$y_{t+1}(y,a,\chi) = a^{\alpha} y^{\beta} (b + S^{\gamma}_{n_t(y,a,\chi)t})\varepsilon, \tag{1}$$

where ε is a iid normally distributed noise with cdf Ψ. Children with higher ability and who grow up in neighborhoods with larger spillover will have higher future income.

Let us now turn to the spillover. We assume that the size of the spillover effect in neighborhood k at time t is equal to a weighted average of the average parental income in the neighborhood and of the average ability of the children growing up there, that is,

$$S_{kt} = \omega E_t[y|n_t(y,a,\chi) = k] + (1-\omega)E_t[a|n_t(y,a,\chi) = k], \tag{2}$$

where ω is the weight assigned to the average parental income, so that if $\omega = 1$ the spillover depends only on average parental income, while if $\omega = 0$ the spillover depends purely on average children ability. The general formulation with $\omega \in (0,1)$ allows us to capture different forces behind neighborhood externalities: some more related to the average parental income, such as the quality of public schools through local taxation, networks, or social norms, and some more related to the average talent of the children growing up in the neighborood, such as peer effects or learning from neighbors' experience. The presence of this externalities implies that the rental rate in neighborhood A, R_{At}, also depends on the relative size of the spillovers in the two neighborhoods, which is endogenous.

Assume that agents can observe the marginal distribution with respect to income by type $F_{y,t}(y|\chi)$ for $\chi \in \{w,b\}$, but cannot observe the marginal distribution with respect to ability by type, $F_{a,t}(a|\chi)$. In particular, they know that it is lognormal, but they do not know the mean and have to form beliefs about it by observing the parental income distribution. In the benchmark model, we assume that all agents are rational, know the income generating process, and can perfectly infer what is the spillover in each neighborhood.

However, the main version of the model, which we label "model with racial bias," introduces a behavioral twist. In particular, white agents do not take into account that parents were exposed to different local

spillover, but instead assume that they were all exposed to the same average spillover $\bar{S}_{t-1}$, that is they assume that

$$y_t = a_{t-1}^{\alpha}(b + \bar{S}_{t-1}^{\gamma}). \tag{3}$$

This implies that when they observe a different parental income distribution for white and black agents, they attribute part of this difference to a different underlying ability distribution. That is, when they observe parental income by race χ, they do the following regressions:

$$E_t[\log(y_t)|\chi] = \alpha E_t[\log(a_{t-1})|\chi] + \beta E_t[\log(y_{t-1})|\chi] + log(b + \bar{S}_t^{\gamma}) + log(\varepsilon), \tag{4}$$

for $\chi = \{w, b\}$. Given the initial conditions, black agents are more concentrated in neighborhood B. However, given that white agents mistakenly assume that all neighborhoods have the same spillover, they attribute part of the difference in average income between black and white agent to differences in average ability. Let us define "racial bias" the perceived average ability gap between white and black parents, that is,

$$\delta_t \equiv E_t[\log(a_{t-1})|\chi = b] - E_t[\log(a_{t-1})|\chi = w]).$$

By using condition 4 for $\chi = w$ and $\chi = b$, we find the endogenous equilibrium racial bias as follows

$$\delta_t = \frac{1}{\alpha}\left[E_t[\log(y_t)|\chi = b] - E_t[\log(y_t)|\chi = w] - \beta\left(E_t[\log(y_{t-1})|\chi = b] - E_t[\log(y_{t-1})|\chi = w]\right)\right].$$

Finally, we assume that black agents are rational, recognize that the correct income process is given in equation (1), and hence understand that the ability distribution is identical for white and black agents. Given that the ability distribution is identical across generations, this implies that while the black agents know the values of the spillovers in the two neighborhoods, the white agents have distorted beliefs about them, because of the racial bias. In particular, $\tilde{S}_{k\chi t}$ denotes the belief of an agent of race χ about the spillover in neighborhood k at time t and is given by

$$\tilde{S}_{k\chi t} = \omega E_t[y|n_t(y,a,\chi) = k] + (1-\omega)E_t^{\chi}[a|n_t(y,a,\chi) = k], \tag{5}$$

where E_t^{χ} means that the average is taken using the beliefs of agent of race χ about the marginal distributions $F_{a,t}(a|\chi)$, which is equal to the effective one $G(a)$ for $\chi = b$, but is equal to the same distribution shifted by $-\delta_t$ for $\chi = w$. This implies that $\tilde{S}_{kbt} = S_{kt}$, while $\tilde{S}_{kwt}$ is generically different from the effective $S_k t$.

Agents' beliefs about the local spillovers are important because they affect the agents' residential choice.

In particular, a parent (y,a,χ) at time t solves the optimal problem

$$U(y,a,\chi) = \max_{c_t, n_t, \tilde{y}_{t+1}} u(c_t) + E_\chi[g(\tilde{y}_{t+1})] \tag{P1}$$

$$s.t.\ \ c_t + R_{n_t t} \leq y \tag{6}$$

$$\tilde{y}_{t+1} = a^\alpha y^\beta (b + \tilde{S}^\gamma_{n_t \chi t})\varepsilon, \tag{7}$$

taking as given R_{kt} and $\tilde{S}_{k\chi t}$ for $k \in \{A,B\}$ and $\chi \in \{w,b\}$, where $\tilde{y}_{t+1}$ is the expected children income.

We are now ready to define an equilibrium. In particular, we focus on equilibria where $R_{At} > R_{Bt}$, that is, equilibria where the spillover in A is higher than the spillover in B.

Definition 1 *For given initial distributions $F_0(y,a|b)$ and $F_0(y,a|w)$, an equilibrium is characterized by a sequence of consumption and residential choices, $\{c_t(y,a,\chi)\}_t$ and $\{n_t(y,a,\chi)\}_t$, a sequence of rents, spillover sizes, and spillover beliefs in neighborhoods A and B, $\{R_{nt}\}_t$, $\{S_{nt}\}_t$, $\{\tilde{S}_{n\chi t}\}_t$ for $n = A,B$ and $\chi = b,w$, and a sequence of distributions $\{F_t(y,a|b)\}_t$ and $\{F_t(y,a|w)\}_t$ that satisfy the following conditions:*

1. *agents' optimization: for each t, the policy functions c_t and n_t solve problem (P1), for given R_{nt} and $\tilde{S}_{n\chi t}$ for $n = A,B$;*

2. *spillovers' consistency: for each t, equation (2) is satisfied for both $n = A,B$;*

3. *spillovers' beliefs: for each t, equation (5) is satisfied for both $n = A,B$, and $\chi = b,w$;*

4. *market clearing: for each t, $R_{Bt} = 0$, and R_{At} ensures housing market clearing in neighborhood A:*

$$\lambda_A R_{At}^{\phi_A} = \mu \int \int_{n_t(y,a,\chi)=A} dF_t(y,a|b)dyda + (1-\mu)\int \int_{n_t(y,a,\chi)=A} dF_t(y,a|w)dyda;$$

5. *income dynamics: for each t and each triplet (y,a,χ):*

$$y_{t+1}(y,a,\chi) = a^\alpha y^\beta (b + S^\gamma_{n_t(y,a,\chi)t})\varepsilon,$$

where ε is an iid normally distributed noise with cdf Ψ.

The key parental choice that shapes the equilibrium allocation is the residential choice that depends on beliefs about the local spillovers. The interesting feature of the equilibrium is that white agents have distorted beliefs about the local spillovers that tend to make them more willing to pay higher rents to live in neighborhoods with lower concentration of black agents.

It is easy to show that the optimal residential policy can be characterized by a race-specific cut-off function

$$n_t(y,a,\chi) = \begin{cases} B \text{ if } y < \hat{y}_{\chi t} \\ A \text{ if } y \geq \hat{y}_{\chi t} \end{cases}. \tag{8}$$

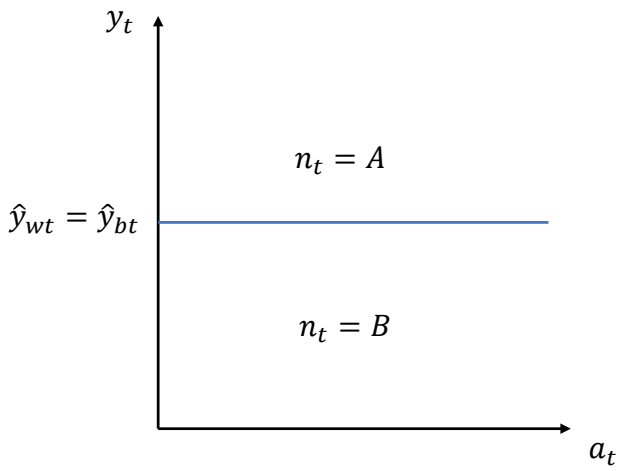
where the cut-off is given by

$$\hat{y}_{\chi t} = R_{At} \frac{b + \tilde{S}^{\gamma}_{A\chi t}}{\tilde{S}^{\gamma}_{A\chi t} - \tilde{S}^{\gamma}_{B\chi t}}. \tag{9}$$

As one would expect, the cut-off is increasing in the rent of neighborhood A, which is the relative cost of living in A. Also it is decreasing in the belief of the spillover in neighborhood A and increasing in the belief of the spillover in neighborhood B, that affect the perceived benefit of living in A. The policy function shows that only agents who are rich enough are willing to pay for the higher rent in order to benefit from the higher local spillover.

In the benchmark case where all agents know the effective size of the spillover in the two neighborhoods, the residential cut-off is the same for white and black agents and $\tilde{S}_{kwt} = \tilde{S}_{kbt} = S_{kt}$ for all k and t. Figure 8 shows the optimal residential choice in this case.

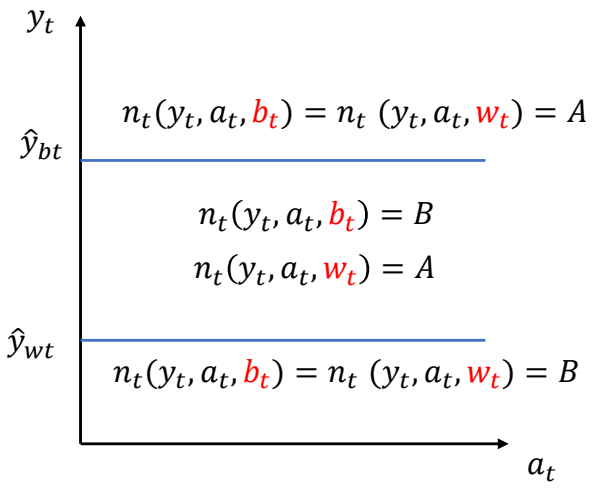
Figure 8: Residential Choice in the Benchmark Model



However, in the model with discrimination, while the black agents still know the effective spillovers, that is, $\tilde{S}_{kbt} = S_{kt}$ for all k and t, the white agents have beliefs about the spillovers in the two neighborhoods that are distorted by their belief that black agents have lower average ability. This implies that they tend to underestimate the spillover in a neighborhood with a higher concentration of black agents. Given our initial condition on the income distribution, we start from a situation where more black agents are poor and so

are more concentrated in neighborhood B. This implies that white agents will underestimate the spillover in neighborhood B and will be willing to pay a higher rent to live in neighborhood A, perpetuating the racial bias. Figure 9 illustrates the residential choice in the model with racial bias.

Figure 9: Residential Choice in the Model with Racial Bias



In the next section, we will use a numerical example to show how the model works. We will first characterize the equilibrium and do some comparative statics. Then, we will do some policy exercises.

4 Numerical Exploration

In this section, we conduct a numerical exploration of the model's properties and results. To begin with, we analyze the dynamic evolution of the model from a given initial condition on the distribution of wages and ability to the steady state. Next, we examine comparative static exercise to illustrate how the key forces of the model, such as the strength of the neighborhood spillovers, affect the steady state. Finally, we explore the role for policy interventions in our model. The parameters used for the numerical analysis are presented in Table 1.

Table 1: Parameter Values

Parameter	Value	Description
μ	0.2	Fraction of black in population
α	0.1	Wage process coefficient on ability
β	0	Wage process coefficient on parental income
b	0.1	Wage process additive coefficient
γ	0.7	Wage process coefficient on spillover
ω	0.5	Spillover coefficient on income
H	0.45	Housing supply in A
σ_ε	0.1	Standard deviation of shock in wage process

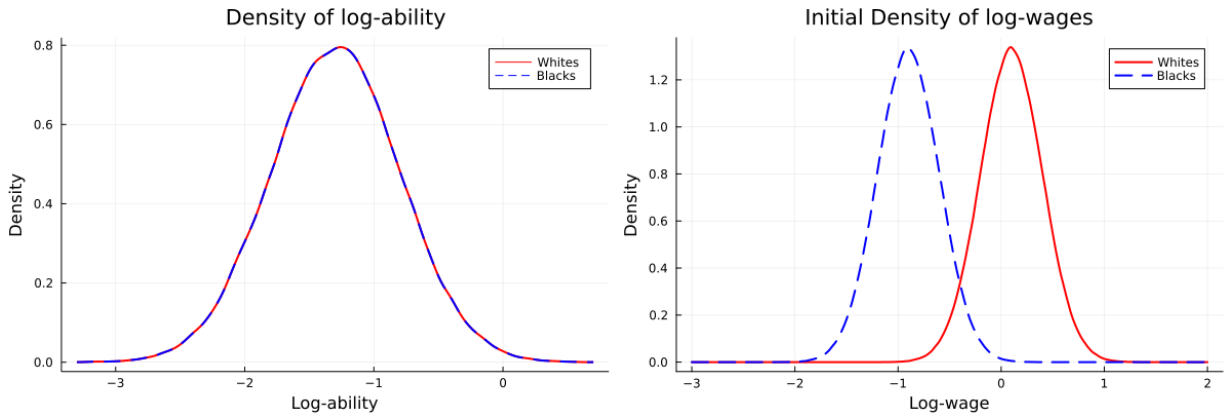
4.1 Wage Gap Dynamics from Unequal Initial Conditions

We begin our numerical exploration by examining the dynamic evolution of the economy starting from given initial distributions of ability and wages, presented in Figure 10. In Panel (a), we display the distribution of log ability, which is identical for both white and black agents. In Panel (b), we show the initial wage distribution, where we assume that, due to historical reasons, the black agents start with an income distribution shifted to the left relative to the white, establishing an initial wage gap. The central question we investigate is whether this wage gap will persist when we solve for equilibrium in the model and under what conditions.

Benchmark Model

We first examine the equilibrium of the model under the assumption that both white and black agents have full information and rational beliefs, so they both correctly assess the spillovers in the two neighborhoods.

Figure 10: Initial Conditions



(a) Density of log ability

(b) Initial Density of log wages

Under this assumption, there is no racial bias, because the white agents correctly assess the average ability of black agents, so we will refer to this as the benchmark model.

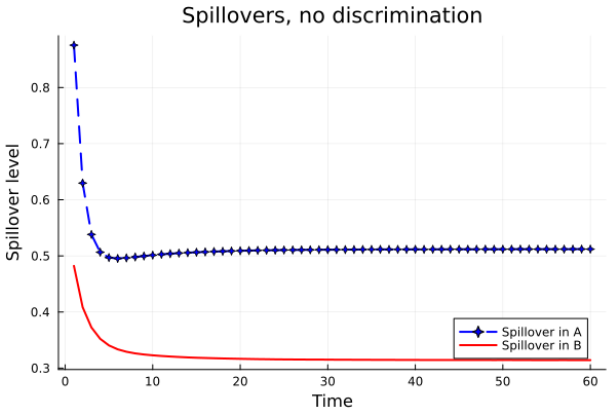
Figure 8 illustrates the residential choice decision rule in the absence of racial bias. In this setting, the decision rule is an income threshold, identical for both black and white agents. All individuals with income above this threshold opt for neighborhood A, while those below it choose neighborhood B.

The implications of the income threshold rule determines the equilibrium spillovers and neighborhood racial composition, presented in Figure 11. In equilibrium, higher-income agents sort to neighborhood A, which results in a higher spillover in A relative to B, as illustrated in Panel (a) of Figure 11 . The higher spillover in A drives up the housing demand, leading to a positive rental rate in A, thus higher than the rent in B, which is normalized to zero. While all agents would enjoy living in the neighborhood with the higher spillover, only the higher-income ones can afford to pay the rent there, so lower income agents are priced out of the neighborhood.

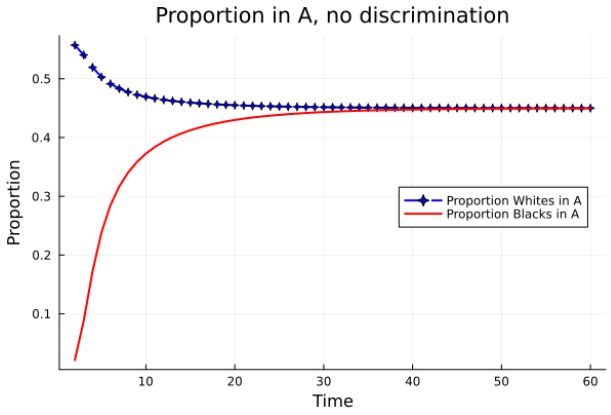
Panel (a) also illustrates the dynamic adjustment of the spillovers toward the steady state. Because the models is initiated from a non-steady-state distribution, the wages, particularly those of the white agents, are too high relative to what the steady state. Thus, spillovers in both neighborhoods initially decline as the wages adjust, but they eventually stabilize. Importantly, the spillover in neighborhood A is always higher than in B.

Although there is no racial bias in this case, the initial conditions - where black agents start with lower average wages - lead to a higher likelihood of black agents falling below the income threshold for choosing

Figure 11: Spillovers and Neighborhood Racial Composition, Benchmark Model



(a) Spillovers, No Discrimination

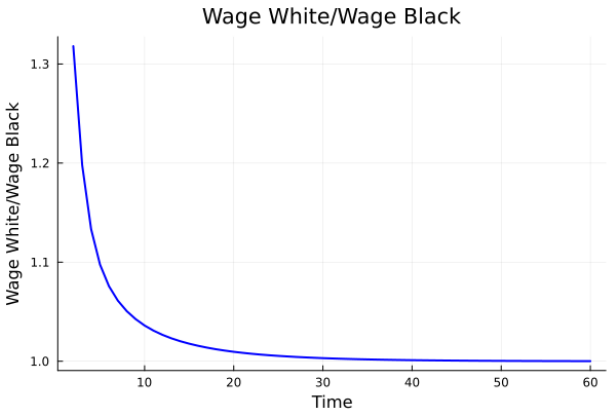


(b) Proportion of Each Race in A, No Discrimination

neighborhood A and thus sorting into B, because they cannot afford the rent in A. This mechanism is illustrated in Panel (b) of Figure 11, which displays the share of agents of each racial group in neighborhood A. The figure confirms that, in early periods, a significantly larger proportion of white agents sort into neighborhood A compared to black agents. However, black agents increasingly gain access to neighborhood A over time as their wages progressively increase, so that racial segregation eventually disappears.

The residential choices and exposure to different spillovers determine the evolution of the white-black wage gap. Figure 12 illustrates the dynamic evolution of the wage gap strating from the initial condition, measured as the average wage of white agents relative to black agents. The figure shows that the wage gap persists for several periods, although it eventually disappears, as the relative wages converge to 1 in the steady state.

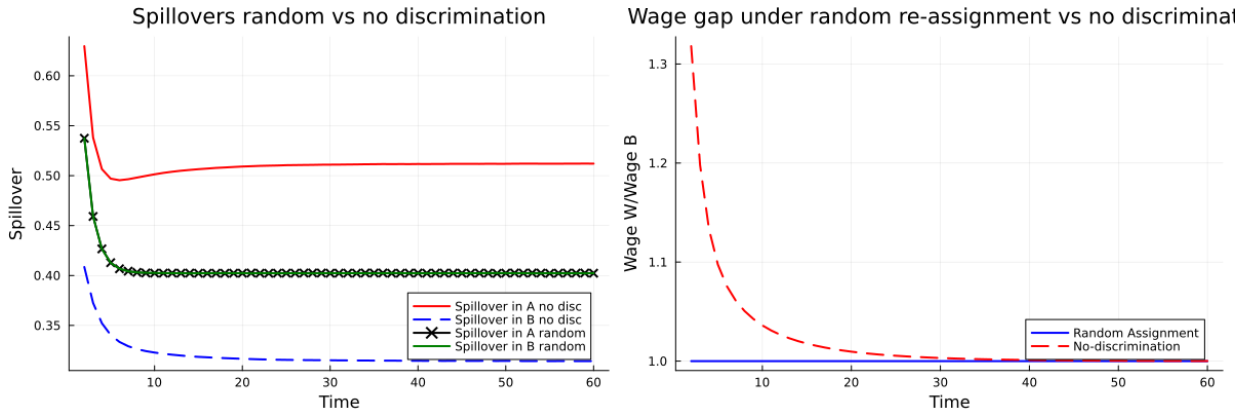
Figure 12: Wage Gap, Benchmark Model



The evolution of the wage gap is explained by two opposing forces. On the one hand, black and white agents have the same fundamental ability distribution, which leads to the convergence in their average ages. On the other hand, black agents have lower wages on average in the initial condition, so they are more likely to sort to neighborhood B, where they are exposed to a lower spillover, which depresses their wage and perpetuates initial wage gap. As a result of the two forces, the wage gap persists for several periods, but it declines monotonically over time, and it eventually disappears, as the former effect dominates in the steady state.

To highlight the role of sorting, in Figure 13 we compare the benchmark model to a scenario where agents are randomly assigned to neighborhoods. Panel (a) shows that, in the random allocation case, spillovers in both neighborhoods are identical due to the uniform distribution of agents by income and ability, as a result of the random assignment. As a consequence of the equalized spillovers across neighborhoods and that the ability distribution is the same for black and white agents, there is no wage gap in the random allocation case, as illustrated in Panel (b). [3] This result emphasizes that residential sorting is the driver of the wage gap in the benchmark model.

Figure 13: Benchmark Model vs. Random Allocation



(a) Spillovers (b) Wage Gap

[3] Note that the wage gap vanishes immediately with random allocation when $\beta = 0$. A positive β, meaning that parental income enters the child's wage process, generates a wage gap with some persistence even with random allocation, but also lower than in the benchmark model.

Model with Racial Bias

In this section, we analyze the model with racial bias, where the white agents do not observe the average ability of the black agents, but need to form beliefs about it in order to infer the spillovers in the two neighborhoods and make their residential choice. The white agents attempt to infer the black agents' average ability from their observed wage distribution. Under our behavioral assumption, the white agents do not know what spillover the black agents were exposed to as children, so they assume that they were exposed to the average spillover in the city. Due to this behavioral assumption, the white agents, observing that the black agents have lower average wages in the initial condition, incorrectly deduce that black agents have lower average ability.

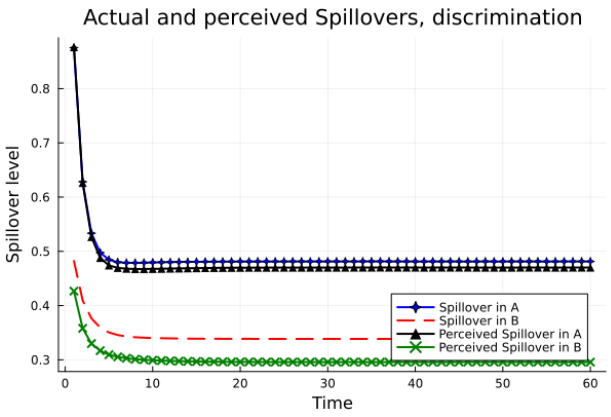
The misperceived ability gap, which we term racial bias, results in white agents perceiving the spillover to be lower than they actually are, as illustrated in Panel (a) of Figure 14. The whites' perceived spillovers in neighborhoods A and B, shown in black and green respectively, are lower than the actual spillovers (blue line for A and red for B). However, the white agents' misperception of the spillover is more severe in neighborhood B, which has a higher initial concentration of black agents, given that they start with lower average wages in the initial condition.

As a result, white agents underestimate the spillover in neighborhood B and are willing to pay a higher rent to live in neighborhood A, as illustrated in Figure 9. The figure shows that racial bias leads to race-specific neighborhood selection thresholds, with a higher threshold - which implies lower willingness to pay- for black agents to access neighborhood A compared to white agents. The richest agents still sort into neighborhood A regardless of race, and the poorest agents sort into neighborhood B. However, in an intermediate income range, black and white agents with identical income and child ability make different location choices: white agents opt for neighborhood A, while black agents remain in neighborhood B.

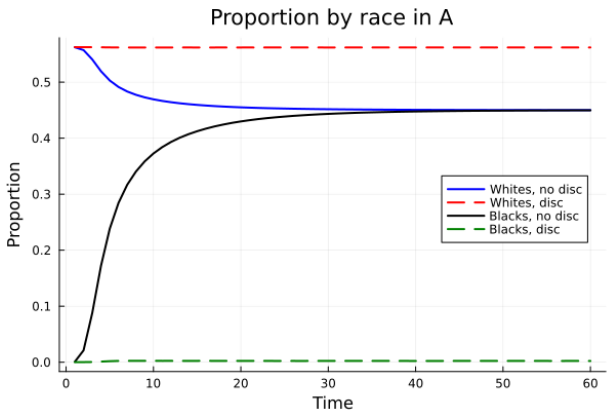
The distorted beliefs and different residential choice thresholds result in racial segregation, as illustrated in Panel (b) of Figure 14. The figure shows that nearly all white agents sort into neighborhood A, while nearly all black agents remain in neighborhood B. Unlike the benchmark case, where segregation gradually disappears, racial segregation is now permanent due to biased racial perceptions.

The long-run effects of racial bias are evident in the evolution of the wage gap. Figure 15 compares the wage gap in the benchmark model (solid red line) and the racial bias model (dashed blue line). While in the benchmark model the wage gap eventually disappears, the model with racial bias produces a permanent

Figure 14: Spillovers and Neighborhood Racial Composition, Model with Racial Bias



(a) Actual and Perceived Spillovers



(b) Proportion of Each Race in A

and amplified wage gap. The wage gap perpetuates because, while the two groups have the same ability distribution, black agents are segregated in the neighborhood with lower spillovers, which depresses their wages. This result highlights that racial bias amplifies the racial wage gap through the mechanism of residential sorting.

Figure 15: Wage Gap, Benchmark vs. Racial Bias Model

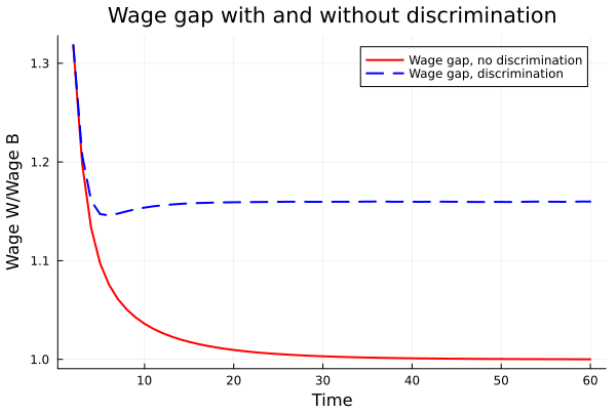
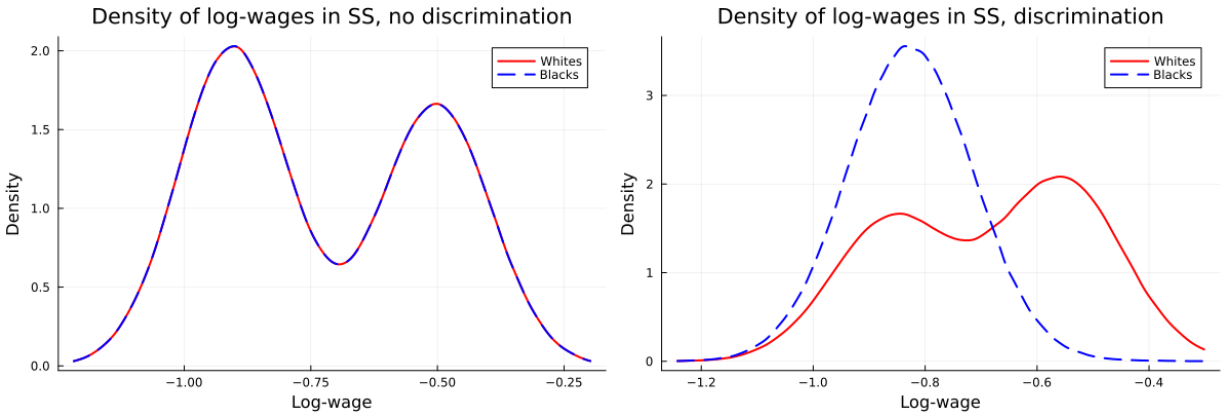


Figure 16 displays the steady-state income distributions, which further illustrate the racial disparities. In the benchmark model, in Panel (a), the steady-state income distributions of white and black agents are identical, as racial segregation and wage inequality disappear. The two peaks in the figure represent agents that live in each of the two neighborhoods. However, with racial bias, in Panel (b), black agents remain concentrated in neighborhood *B*, and their income distribution remains permanently shifted to the left relative to the white agents. The white agents' distribution (red solid line) displays two peaks, with a some

white agents in neighborhood B, but the majority of them in A, benefiting from a higher spillover. On the contrary, the black agent's distribution has a single peak, as all these agents are segregated in neighborhood B in the steady state.

Figure 16: Steady State Wage Distribution, Benchmark vs. Racial Bias Model



(a) Benchmark Model

(b) Racial Bias Model

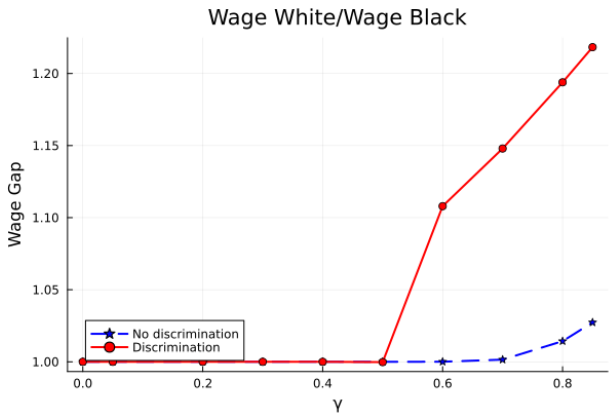
4.2 Comparative Statics

Under what conditions does the wage gap persist? In this section, we investigate which forces in the model determine the amplification and persistence of the wage gaps.

We first investigate the role of the strength of the spillovers in the wage process, captured by the parameter γ. Figure 17 presents the steady-state wage gap associated with different values of γ in the benchmark model (blue dashed line) and in the racial bias model (red solid line). For low values of γ, there is no wage gap with and without racial bias. However, for intermediate values of γ, the benchmark model results in no wage gap, whereas the model with racial bias generates a permanent wage gap, which is the case presented in the previous section. For sufficiently large values of γ, the wage gap is permanent in both models, but is substantially larger under racial bias. These results underscore the importance of the strength of the local externality, captured by γ, as a determinant of the magnitude and persistence of the steady-state wage gap.

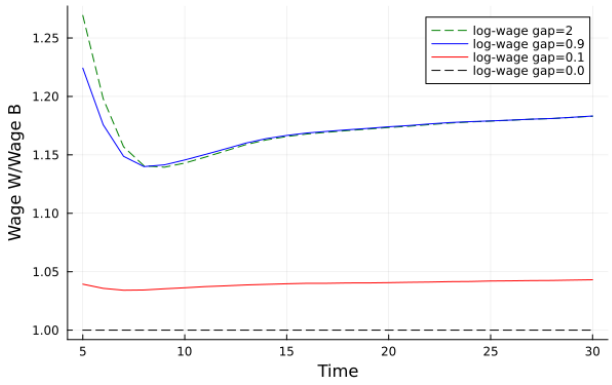
Next, we examine the role of initial conditions in determining equilibrium outcomes. Figure 18 plots the dynamics from different initial wage gaps to the steady-state in the model with racial bias, while keeping all parameters fixed. The results indicate the presence of multiple steady states: depending on the initial condition, the economy converges to different levels of steady-state wage gaps. We observe that there may

Figure 17: Comparative Statics: Spillovers Strength and Wage Gap



be ranges of initial conditions that lead to the same steady states (green and blue line). On the other hand, lower initial wage gaps may lead to permanently lower gaps (red line). This finding suggests that there is path dependence, because higher initial inequality leads to permanently higher wage gaps.

Figure 18: Multiple Steady States



4.3 Policy Intervention

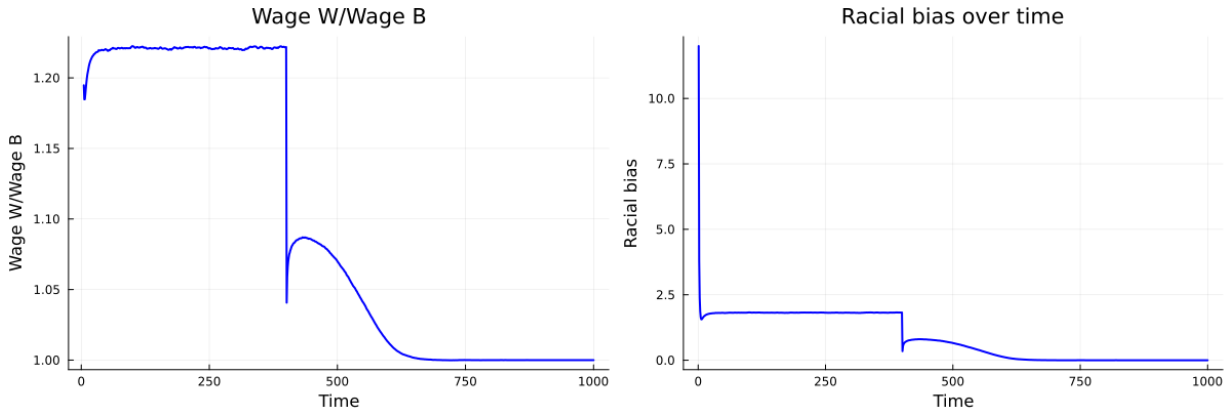
The existence of multiple steady states opens the door for potential policy interventions to shift a segregated economy toward a steady state with lower racial segregation and wage gap. While there are many possible policies that could reach this goal, here we explore a simple reparations policy, which may not be the optimal policy, but let use illustrate how an intervention can move the economy to a different steady state.

We introduce a one-time reparations policy, which imposes a proportional income tax on all white agents and redistributes the collected resources as a lump-sum transfer to all black agents. Figure 19 in panel

(a) shows the wage gap before and after the intervention. Prior to the policy, introduced at time T = 400, the economy exhibits a persistent wage gap exceeding 20%. Upon implementing reparations, the immediate effect is a reduction in the wage gap due to the direct income transfer. However, beyond this mechanical effect, the redistribution allows black agents to afford and move to neighborhood *A*, improving their exposure to spillovers, which improves their wages and triggers a self-reinforcing cycle of economic improvement. After an initial overshooting, the economy transitions to a new steady state where the wage gap fully disappears.

Panel (b) explores the effects on racial bias. Initially, distorted beliefs perpetuate segregation. However, following reparations, increased integration in neighborhood A reduces biased perceptions over time. Ultimately, the economy reaches a steady state with no racial bias, demonstrating that a single intervention can not only eliminate wage inequality but also reshape social attitudes over the long run.

Figure 19: Reparations



(a) Wage Gap

(b) Racial Bias

5 Conclusion

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