Neighborhood Dynamics and the Distribution of Opportunity

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Abstract: This paper uses an overlapping-generations dynamic general equilibrium model of residential sorting and intergenerational human capital accumulation to investigate effects of neighborhood externalities. In the model, households choose where to live and how much to invest toward the production of their child's human capital. The return on parent's investment is determined in part by the child's ability and in part by an externality from the average human capital in their neighborhood. We use the model to test a prominent hypothesis about the concentration of poverty within racially-segregated neighborhoods (Wilson (1987)). We first impose segregation on a model with two neighborhoods and match the model steady state to income and housing data from Chicago in 1960. Next, we lift the restriction on moving and compute the new steady state and corresponding transition path. The transition implied by the model qualitatively supports Wilson's hypothesis: high-income residents of the low average human capital neighborhood move out, reducing the returns to investment in their old neighborhood. Sorting increases city-wide human capital, but it also produces congestion in the high income neighborhood, increasing the average cost of housing. As a result, average welfare decreases by 2.2 percent of steady state consumption, and the loss is greatest for those initially in the low income neighborhood.

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1 Introduction

A great deal of public policy is focused on improving outcomes like educational attainment and income, despite the fact that we do not have a clear empirical picture of what drives inequality of outcomes. In theory, both immutable factors like preferences and ability as well as environmental factors play a role in driving inequality. Policy is often motivated by a normative desire to equalize those environmental factors thought of as opportunity, such as safety, access to education and health care, and employment networks. However, policy is typically implemented using outcomes because it is difficult to empirically distinguish the role of opportunity from that of the other factors shaping outcomes.

Empirically documenting what drives the distribution of opportunity is crucial for determining what policies, if any, might help move society towards greater equality of opportunity, and what costs such policies are likely to incur upon society. Neighborhood externalities in combination with residential sorting are widely considered to be one of the major determinants of the distribution of opportunity. Yet despite suggestive correlations, the endogeneity of residential location makes the identification of neighborhood effects complicated.[1] Spatial correlations in outcomes could reflect spatial correlations in opportunity, but they could also reflect residential sorting by preferences or ability, and it is difficult to imagine scenarios where this issue is completely resolved.

The history of racial segregation in the United States provides a unique circumstance for studying neighborhood externalities: The endogeneity of neighborhood sorting was heavily restricted for decades and then unrestricted from initial conditions of extreme inequality. Furthermore, this issue is not only of historical interest: blacks still tend to live in lower quality neighborhoods than their white counterparts as measured along several dimensions.[2]

A large literature has studied the role of neighborhood effects in persistent racial disparities since Wilson (1987)'s analysis of the concentration of poverty in Chicago between 1970 and 1980.[3] Wilson hypothesized that under segregation high income African Americans contributed positively to their neighborhoods through an externality which increased the return to investment in human capital. Opportunities decreased in these neighborhoods after the end of legal segregation allowed for the outmigration of high income households, producing persistent poverty by discouraging investment in human capital.

Despite the dynamic nature of Wilson's hypothesis, most related empirical research has approached it from a static perspective. The microeconometric literature has focused on finding cross-sectional evidence of neighborhood effects (Sampson et al. (2002), Aliprantis (2012)) or specifying and estimating static models of residential sorting (Ioannides (2010), Bayer et al. (2007)). Few studies have used quantitative macroeconomic tools to study these issues. Fernandez and Rogerson (1998) examine changes to public school financing in a political economy model. Most similar to our analysis is Badel (2010), which examines steady state differences in black and white wages driven by neighborhood externalities and race preferences.[4]

[1] There are actually two separate challenges to empirically informing a theory of inequality of outcomes. One is determining the relative importance of immutable versus environmental factors, and the other is determining which factors are most important within each of these categories.

[2] For example, blacks tend to live in neighborhoods with much higher poverty rates (even conditional on poverty status) or male unemployment rates than their white counterparts. See Figures 1 and 2.

[3] Some other explanations social scientists have used to explain persistent racial disparities include statistical and taste-based discrimination (Fang and Moro (2010), Bertrand and Mullainathan (2004)), identity (Fang and Loury (2005)), and differences in the conditional distributions of ability (Zuberi (2001), Goldberger and Manski (1995)).

[4] There is also a well-developed related theoretical literature. Most directly related to our analysis is Lundberg and Startz (1998), and also related are Bénabou (1996), Bénabou (1993), Durlauf (1996), Glomm and Ravikumar (1992), Bowles et al. (2009), and Epple and Romano (1998).

This paper tests Wilson's hypothesis using an overlapping-generations dynamic general equilibrium model of residential sorting and intergenerational human capital accumulation. In the model, households choose where to live and how much to invest toward the production of their child's human capital. The return on parent's investment is determined in part by the child's ability and in part by an externality from the average human capital in their neighborhood. The lifetime earnings that a household receives is a function of their human capital, and adults get utility from consuming an aggregate consumption good and housing services, and the discounted expected utility their descendants get from consuming goods and housing. Our analysis contributes to the literature by casting Wilson's hypothesis in terms of agents who are forward looking to anticipate the rise and decline of neighborhoods. Agents in our model choose both neighborhoods and individual investment levels taking into account expected future behaviors of other agents.

We calibrate the model to a steady state with no moving between two neighborhoods with different production function parameters using Census data from Chicago in 1960. We are able to empirically match the endogenous, cross-sectional income distributions of this initial steady state. We then remove the moving restriction and compute the transition to a new steady state. The transition path predicted by the model matches Wilson's hypothesis: high human capital households move from the low income neighborhood into the high income neighborhood, decreasing the human capital stock, and therefore the return on investment in the low income neighborhood. Income distributions predicted by the model qualitatively match Census data from Chicago between 1960 and 1990.

Our model permits us to calculate the welfare implications of policy changes, and doing so also helps to illustrate the two competing externalities driving outcomes. One externality increases the productivity of investments in human capital, while the other increases the price of housing, and therefore the price of access to this improved technology. Depending on their own ability and human capital, and the choices of other agents, agents in the model decide whether to move based on which externality outweighs the other for them.

Allowing sorting decreases average welfare by 2.2 percent of steady state consumption.[5] In the high income neighborhood this decrease comes from a temporary decrease in the human capital externality and rising house prices due to immigration from the low income neighborhood. In addition, the city-wide wage decreases as aggregate human capital increases. Perhaps surprisingly, the average welfare loss is greater in the low income neighborhood. Not only are these households affected by the wage decrease, but those that leave face a higher house price, while those that remain suffer from the erosion of neighborhood human capital.

The remainder of the paper is structured as follows: Section 2 presents a dynamic general equilibrium model of neighborhood dynamics and human capital accumulation. Section 3 presents the results of the numerical experiment we implement with this model. This Section includes a discussion of the data to which the model is calibrated. Section 3 also compares distributions from the data with those implied by the model's steady state equilibria and its transition between those equilibria. Finally, Section 3.4 compares welfare under the steady state and transition. Section 4 concludes.

[5]The model is a parsimonious representation of neighborhood sorting and externalities; it is not used to make normative statements about the history of racial integration in the US.

2 A Model of Neighborhood Dynamics and Human Capital Accumulation

We now present a dynamic general equilibrium model building on Bewley (1986) and Aiyagari (1994) that incorporates the intergenerational accumulation of human capital together with both neighborhood sorting and a neighborhood externality in the production of human capital.

2.1 Households

There is a unit continuum of overlapping generation households within a city which is divided into K neighborhoods. Each household consists of two individuals, a parent and a child. All individuals live for two periods: at the end of each period adults die, children become adults, and each household has a new child. Adults receive utility from their consumption of an aggregate consumption good ($c \in \mathbb{R}^+$), consumption of housing units whose characteristics are ordered according to a single housing quality index ($s \in \mathbb{R}^+$), and the discounted expected utility of their offspring. Children receive no utility from household decisions, however parents are altruistic; therefore, a household is functionally identical to an infinitely-lived dynasty. Preferences for a dynasty take the form

$$U(c, s) = E_0 \sum_{t=0}^{\infty} \beta^t u(c_t, s_t).$$

Note that β, the discount factor between a parent and its offspring, incorporates both altruism and time preferences. Children are born with innate ability, a, for producing human capital. The log of a follows an AR(1) process

$$\log(a') = \rho_a \log(a) + \varepsilon_a, \quad \varepsilon_a \sim LN\left(0, \sigma_a^2\right),$$

and there is no insurance against having a low-ability child.

2.1.1 The Household's Problem

Each household is characterized by its state vector (h, a, k), where $h \in \mathbb{H} \subset \mathbb{R}^+$ is the human capital level of its adult, $a \in \mathbb{A} \subset \mathbb{R}^+$ is the ability of its child, and $k \in K = \{1, \ldots, \overline{K}\}$ is the neighborhood in which the household begins the period. Each neighborhood is characterized by its distribution of human capital ($\Gamma_k(h, a)$) and a housing price (p_k). The household chooses a neighborhood $\bar{k}$ in which to live ($\bar{k}$ may be k). After the location decision has been made, the adult chooses consumption, housing, and investment in its child. Units of housing, s, are rented from an absentee landlord at the neighborhood-specific price $p_{\overline{k}}$. At the end of each period, all houses are destroyed and must be rebuilt; children cannot inherit a house from their parents. The parent supplies 1 unit of labor, earning income equal to its human capital multiplied by the city-wide wage w. The period budget constraint for a household living in neighborhood $\bar{k}$ is

$$c + i + p_{\overline{k}} s \leq wh. \tag{1}$$

2.2 Human Capital Production Function

Following Badel (2010), a dynasty's human capital evolves according to a function that depends upon the parent's human capital, the parent's investment, the child's ability, and the per-capita

level of human capital in the adult's neighborhood, $H_{\bar{k}}$. A parent passes on a fraction $(1-\delta)$ of its human wealth to the child:[6]

$$h' = (1-\delta)h + aF_{\bar{k}}(i, H_{\bar{k}}). \tag{2}$$

Note that F is neighborhood-specific, which is a central assumption of the model. Differences in neighborhood steady states can only exist if neighborhoods differ in either household preferences, the ability process, or the human capital production function.[7] Our model assumes the final explanation. These differences could arise from many sources like racial discrimination, political economy over resources, crime, social capital, or a deficiency of public services. We discuss this assumption with respect to our application in Section 3.

Because the technology for transforming investment into human capital tomorrow is neighborhood-specific, the distribution of human capital for each neighborhood evolves according to its own transition rule,

$$\Gamma'_k = \Psi_k\left(\Gamma_k\right). \tag{3}$$

Furthermore, because households may choose to move, the human capital distributions of each neighborhood may change within a period. Denote this *intratemporal* human capital distribution, $\tilde{\Gamma}$. Ψ_k is a composite function of $\tilde{\Psi}_k$ and $\hat{\Psi}_k$, where the first accounts for sorting and maps Γ_k to $\tilde{\Gamma}_k$ and the second applies the capital evolution equation and maps $\tilde{\Gamma}_k$ to Γ'_k. It is important to draw this distinction because Ψ_k will change depending upon the sorting rules permitted. Figure 3 shows a timeline of the evolution of these distributions.

2.3 The Firm

The firm supplies consumption, investment, and housing units. It rents labor from a competitive city-wide market at wage,

$$w = \alpha N^{\alpha-1},\ 0 < \alpha < 1, \tag{4}$$

where N is the city-wide supply of labor, and takes the market clearing price for housing as given in both neighborhoods.[8] Given w and p_k, the firm chooses how much housing labor, Q, to allocate to each neighborhood so as to maximize profits.

Specifically, the firm's problem is

$$\max_{Q_k} \sum\nolimits_{k\in K} \left(p_k Q_k^{\alpha} - wQ_k\right).$$

The first-order condition implies that for any neighborhood k

$$\alpha p_k Q_k^{\alpha-1} = w.$$

And since p_k clears the market for each neighborhood,

$$p_k = \frac{w}{\alpha}\left(S_k\right)^{\frac{\alpha-1}{\alpha}}, \tag{5}$$

[6] Although we allow for parent's to directly transfer human capital to their children, we set δ to 1 in the numerical experiment.

[7] See Kremer (1997) for a related model in which sorting has negligible implications for steady state inequality when it is assumed there is a constant technology across neighborhoods.

[8] With inelastic labor supply, aggregate labor input for any neighborhood equals its average human capital multiplied by its population share ($N_k = \psi_k H_k$).

where S_k is the total housing units demanded in equilbrium in community k.

2.4 Recursive Formulation

2.4.1 Equilibrium under Segregation (SRCE)

This paper examines the effects of removing barriers to neighborhood sorting. Initially, households will be prohibited from moving across neighborhoods (i.e., $\bar{k} = k$). In this case, the model economy is a collection of segregated economies connected only through the wage. The household's problem can be expressed recursively as

$$V(h, a, k) = \max_{c,i,s} \; u(c, s) + \beta EV\left(h', a', k'\right) \tag{6}$$

subject to (1)-(5), and a restricted form of (3):

$$\Gamma'_k = \Psi_k(\Gamma_k) = \hat{\Psi}_k(\Gamma_k). \tag{7}$$

In addition to its individual state variable, (h, a, k), a household must also have knowledge of the distribution of human capital in each neighborhood, $\{\Gamma_k\}_{k\in K}$, in order to quantify the neighborhood externaltiy F_k and the aggregate wage. We now define a *recursive competitive equilibrium under segregation* (SRCE).

Definition 1. *Given initial distributions $\{\Gamma_{0,k}\}_{k\in K}$, an SRCE is a set of value functions V, policy functions g_c, g_i, and g_s, transition rules Ψ_k, and pricing functions $p_k(\Gamma_k), w\left(\{\Gamma_k\}_{k\in K}\right)$ such that*

1. Given prices and transition rules, $V(h, a, k)$, $g_c(h, a, k)$, $g_i(h, a, k)$, and $g_s(h, a, k)$ solve (6).
2. The firm maximizes profits:
$$w = \alpha N^{\alpha-1}$$
and
$$p_k = \frac{w}{\alpha}(S_k)^{\frac{\alpha-1}{\alpha}}.$$
3. The housing market clears in each neighborhood:
$$S_k = \int g_s(h, a, k)\, d\Gamma(h, a, k) \;\; , \;\; \forall k \in K$$
4. Ψ_k is consistent with the investment decisions, child abilities, and per-capita human capital in neighborhood k.
5. The goods market clears:
$$\int g_c(h, a, k) + \int g_i(h, a, k) + \int g_s(h, a, k) = N^{\alpha}.$$

2.4.2 Equilibrium with Moving (MRCE)

Once moving restrictions are lifted, then (7) returns to its general form in (3):

$$\Gamma'_k = \Psi_k\left(\Gamma_k\right) = \hat{\Psi}_k\left(\tilde{\Psi}_k\left(\Gamma_k\right)\right). \tag{8}$$

This requires amending slightly the household problem above as

$$\bar{V}\left(h,a,k\right) = \max_k \left\{ \max_{c,i,s} \; u\left(c,s\right) + \beta E\bar{V}\left(h',a',k'\right) \right\} \tag{9}$$

subject to (1)-(5). An equilibrium when moving restrictions are lifted is also different than an SRCE.

Definition 2. *Given initial distributions $\{\Gamma_{0,k}\}_{k\in K}$, a recursive competitive equilibrium with moving (MRCE) is a set of value functions $\bar{V}$, policy functions $\bar{g}_c$, $\bar{g}_i$, $\bar{g}_s$, and $\bar{g}_k$,transition rules $\hat{\Psi}_k$ and $\tilde{\Psi}_k$, and pricing functions $p_k\left(\tilde{\Gamma}_k\right), w\left(\{\Gamma_k\}_{k\in K}\right)$ such that*

1. Given prices and transition rules, $\bar{V}(h,a,k)$and $\bar{g}_c(h,a,k)$, $\bar{g}_i(h,a,k)$, $\bar{g}_s\left(h,a,k\right)$, and $\bar{g}_k\left(h,a,k\right)$ solve (9).
2. The firm maximizes profits.
3. The housing market clears in each neighborhood:

$$S_k = \int \bar{g}_s\left(h,a,k\right) d\tilde{\Gamma}_k\left(h,a\right) \;\; , \; \forall k \in K.$$

4. $\tilde{\Psi}_k$ is consistent with the moving decisions of households initially in k.
5. $\hat{\Psi}_k$ is consistent with the investment decisions, child abilities, and per-capita human capital in neighborhood k.
6. The goods market clears:

$$\int \bar{g}_c\left(h,a,k\right) + \int \bar{g}_i\left(h,a,k\right) + \int \bar{g}_s\left(h,a,k\right) = N^{\alpha}.$$

3 Numerical Experiment

We initialize our model by solving for a steady state with no moving that matches some statistics from Chicago in 1960. We then remove the barrier to residential choice and solve for the transition to the new steady state.

We use 1960 as the baseline because years of racially discriminatory housing practices had produced two distinct neighborhoods within Chicago by that time: a lower average income neighborhood with a high concentration of African-Americans and a higher average income one with a very low concentration of African-Americans. Furthermore, the key civil rights legislation that

lifted the barrier to moving was enacted in the 1960s.[9] We study Chicago because of its prominence in research on neighborhood effects and in the African-American experience.

Period utility is assumed to be

$$u(c, s) = \log(c_t) + \theta \log(s_t),$$

so that the intertemporal elasticity of substitution in consumption and the curvature of utility with respect to housing are unity. F_k is assumed to be CES for all k:

$$h' = (1 - \delta)h + aA[\lambda_k i^\gamma + H_k^\gamma]^{\frac{1}{\gamma}}. \tag{10}$$

From an examination of the US in the first part of the 20th century it is reasonable to infer that under segregation black and white neighborhoods faced different technologies for the intergenerational transmission of human capital. Since this assumption and the others that can generate differences across neighborhoods in the steady state equilibria of our model have been controversial, Appendix A presents a brief review of the historical evidence on segregation and discrimination in support of this assumption.

3.1 Data and Variables

We fit the model to three variables that we create from tract-level decennial census data between 1960 and 1990 from the National Historical Geographic Information System (Minnesota Population Center (2004)). The first variable is the share of African-American residents in each census tract, which we use to define the neighborhoods in a city. This variable is created by dividing the total number of African-Americans in each tract by the total number of residents.

Neighborhood 1 is defined in 1960 as all census tracts with a share black greater than or equal to 0.80, and neighborhood 2 is defined as all remaining census tracts in the city. Census tracts are part of neighborhood 1 in subsequent years if they are contained within 1960's neighborhood 1. Figures 4a and 4b show the share black in Chicago census tracts in 1960 and 1990. We can see that neighborhood 1 contains Chicago's "Black Belt," the segregated area in which most of the city's African Americans lived. Appendix A provides a discussion of our definition of neighborhoods along with descriptive statistics for related variables outside of the model for both neighborhoods between 1960 and 1990.

The second variable is per-capita income, from which we construct the distribution of human capital. In each year this variable is created as the aggregate income in each census tract divided by the total number of residents and then converted to 2005 dollars using the the appropriate BEA GDP price deflator. In 1960 and 1970 aggregate income is created from variables on the income of families and unrelated individuals, and in 1980 and 1990 aggregate income is created from variables on household income. Income is also de-trended since there is no growth in our model.[10] De-trended income is real per-capita income multiplied by the ratio of the average per-capita income in Chicago in 1960 to that during the year in question.

The last variable used to fit the model is a measure of the per-capita value of owner-occupied units in a neighborhood. We do not use rental prices because it is difficult to scale these prices into

[9] Some important civil rights legislation includes the Civil Rights Act of 1964, the Voting Rights Act of 1965, and the Fair Housing Act of 1968. Some important Supreme Court cases related to civil rights include Brown v. Board of Education (1954), Swann v. Charlotte-Mecklenburg Board of Education (1971), Milliken v. Bradley (1974), Hills v. Gautreaux (1976), and Parents Involved in Community Schools v. Seattle School District No. 1 (2007).

[10] See Guerrieri et al. (2012) for a model in which income shocks help drive residential sorting.

a lifetime measure. We also use the share of owner-occupied units to scale this variable since there are likely to be more renters in neighborhood 1 than in neighborhood 2.

3.2 1960 Steady State

Our model has nine paramaters. We set δ to 1 and the labor share, α, to 0.64. This leaves the utility parameters β and θ, the human capital production parameters, λ_1, λ_2, and γ, and the parameters governing the stochastic process of ability ρ and σ_a. θ can be identified from the intratemporal condition for housing

$$\theta = \frac{pq}{c}.$$

The ratio of housing services to consumption in 1960 is 0.166 in the NIPA accounts.The remaining six parameters are calibrated jointly to match six inter-neighborhood and intra-neighborhood inequality measures. Table 1 lists the values of the parameters of the calibrated model.

The model fit is shown in Figure 5a and Table 2. Figure 5a plots the distribution of per-capita income for each neighborhood in the 1960 data against its model counterpart from the calibrated steady state. Given the relatively small number of adjustable parameters, we feel that the model does a good job of capturing inequality in both neighborhoods. In particular, the model well-approximates the distribution for neighborhood 1, the focus of this paper. Table 2 reports the moments of these distributions used to calibrate the model, both in the data and as implied by the calibrated model.

3.3 Transition

Qualitatively, the model transition is consistent with the hypothesis of Wilson (1987). High human capital residents in neighborhood 1 exit to neighborhood 2, leading to a precipitous decline in neighborhood 1's human capital.

The secular patterns in the data are shown in Table 3 and Figure 5b. The ratio of average human capital in neighborhood 1 to that in neighborhood 2 begins in 1960 at 0.56, falls to 0.49 by 1980, and falls all the way to 0.41 by 1990. The share of Chicago's overall population living in neighborhood 1 declines over this period from 11 percent to 4 percent. Similarly, the share of Chicago's African American population that resides in neighborhood 1 declines from 75 percent in 1960 to 21 percent in 1990.

Without any moving frictions the model qualitatively matches Wilson's hypothesis, but the transition appears faster than that found in the data. In the first period of the the reform, 69 percent of neighborhood 1 moves to neighborhood 2. These migrants come entirely from the upper tail of the neighborhood 1 human capital distribution. On average, their human capital is 26.6, or 112 percent of the initial neighborhood level. This exodus of high human capital households reduces the neighborhood externality, making human capital accumulation more costly for those remaining. This induces the upper tail of those that stay to move out in the next period. Figure 6a plots the critical h^* value across household ability levels at which the household exits neighborhood 1 in some early periods of transition. For a given line, all h values above the line are movers. While there is some difference in h^* across a in the first period, the line quickly flattens out. Also, the concentration of movers in the right tail of the h distribution is evident. The critical human wealth level decreases over time for all ability types, until by the 5th period when nearly every (h, a) combination would choose to exit.[11] Neighborhood 1 is empty after five model periods of

[11] Some households move from neighborhood 2 into neighborhood 1 taking advantage of lower house prices, however, their combined population mass is very small, only 0.38 percent. In addition, these households come from the

transition.

The effect of this migration on aggregates and prices in neighborhood 1 is straightforward. Figure 7a plots the transition paths of per capita level of human capital, the quantity of housing, the price of housing, and the population. The picture is one of rapid, self-reinforcing flight. As population exits and human capital erodes, housing demand declines, pushing prices down. Since there are no frictions to moving, the decline in prices is the reason why the entire population from neighborhood 1 does not migrate to neighborhood 2 in the first period. As can be seen from Figure 7b, the house price in neighborhood 2 is considerably higher and grows as households immigrate. Moving from 1 to 2 then requires a downward adjustment in house size and consumption, implying a tradeoff between smoothing consumption and maintaining human capital. Initially the higher return to investment in human capital in neighborhood 2 does not warrant the disruption in consumption and housing. However, as higher income households leave, and the disparity between human capital formation technologies grows, more households find moving optimal.

The welfare effects of opening the economy to residential sorting are examined in Section 3.4, however, the transition dynamics of the neighborhood 2 aggregates point to three costs to its initial residents. First is that in the early periods of transition, the per capita human capital level in neighborhood 2 decreases as lower human capital households are absorbed from neighborhood 1. Over time, these new households increase their investment causing the average level to rebound; however during the transition, the return to investment in human capital is lower than in the initial steady state. Second, with new entrants, housing demand rises, increasing the price of housing. Finally, as shown in Figure 6b, as aggregate human capital increases, the wage falls. In effect, for a large number of households initially in neighborhood 2 removing barriers to sorting only imposes costs.[12] The transition implied by the model is also reported in Table 4 and Figure 8.

3.4 Welfare

For every possible combination of states in the initial steady state, we calculate the change in welfare a household experiences by transitioning to the steady state with residential mobility. Similar to Lucas (1987), we measure the welfare change as the percentage of initial steady state consumption necessary to make the household indifferent between transitioning along an MRCE or remaining at the segregated SRCE. Call this consumption compensation Δ. We define the welfare from a given Δ as

$$V^{comp}\left(h,a;k,\Delta\right)=\log\left(\left(1+\Delta\right)g_c\left(h,a;k\right)\right)+\theta\log\left(g_s\left(h,a;k\right)\right)+\beta E_{a'|a}V^{comp}\left(h',a';k\right)$$

$$\begin{aligned} s.t.\ wh &\geq g_c\left(h,a;k\right)+g_i\left(h,a;k\right)+p_k g_s\left(h,a;k\right) \\ h' &= (1-\delta)h+aF_{\bar{k}}(g_i\left(h,a;k\right),H_{\bar{k}}) \end{aligned}$$

where prices, aggregates, and the decision rules g_c, g_s, and g_i are those from the SRCE defined in (6). We solve for the Δ^* that makes a household indifferent between staying at the current SRCE steady state or allowing for moving and transitioning along the MRCE path. Δ^* satisfies

$$V^{comp}\left(h,a;k,\Delta^*\right)=\bar{V}\left(h,a,k\right)$$

lower tail of the income distribution, averaging 72 percent and 46 percent of the initial per capital human capital in neighborhood 1 and neighborhood 2, respectively, so their movement only reinforces the city-wide migration dynamic.

[12] The few households that initially move out of neighborhood 2 to take advantage of cheap housing get some benefit.

where $\bar{V}(h, a, k)$ is the value to a household with state vector (h, a, k) when moving restrictions are lifted. In other words, $\bar{V}(h, a, k)$ captures not only utility from the final steady state but also from the transition. The city-wide average consumption compensation is -2.2 percent, indicating that undergoing the transition is welfare reducing on average. Counterintutively, the average change in neighborhood 1 is -4.8 percent, while it is only -1.9 percent in neighborhood 2. In fact, Δ^* is negative for 99.99 percent of households, suggesting that if policy were put up to a vote in our model, segregation would receive overwhelming support.[13]

The size of the welfare changes are not evenly distributed. For a household with a very low level of human capital the welfare gain is positive and potentially very large, especially for those beginning the transition in neighborhood 2 because these households take advantage of plummeting house prices in neighborhood 1. The gain for the poor, however, quickly diminishes and becomes negative. As income rises, the welfare change increases for those initially in neighborhood 1, becoming as large as 10 percent for a high ability household with 41 times the average human capital level. For these households, the cost of maintaining an extremely high human capital level is greatly reduced by access to the larger neighborhood 2 externality. In contrast, the extremely rich initial incumbents of neighborhood 2 suffer slight welfare declines. Again, every aspect of the transition is negative for them. They remain in neighborhood 2 the entire time, incurring higher prices for housing, a slightly reduced externality, and a wage decline. Importantly, there is almost no population mass in either the very poor region or the extremely rich region of the state space. Table 5 displays the human capital levels at several percentiles of the initial steady state human capital distribution in each neighborhood.

Even though the model implies that the extremes of income would likely benefit from opening to sorting, we do not find this empirically relevant for the case studied here. Nevertheless, such considerations may be salient for studies of other residential sorting populations where initial income inequality is even more extreme. Comparing across ability types in Table 6, those with high ability are hurt less than lower ability types. The positive relationship between a and Δ^* is in part attributable to the fact that higher ability households have higher human wealth and so are less likely to spend time in neighborhood 1 during the transition.

Finally, note that these calculations do not take into account changes in the welfare of the absentee landlord. As a measure of these changes we do compute the present discounted value of producer surplus. Under the policy change, which includes the transition path, producer surplus decreases by 1.8 percent compared to remaining in the initial steady state.

There are essentially two competing externalities driving outcomes in the model. One externality increases the productivity of investments in human capital, while the other increases the price of housing, and therefore the price of access to this improved technology. Depending on their ability and human capital, and the choices of other agents, agents in the model decide whether to move based on which externality outweighs the other for them. It should be stressed that households have full knowledge of the effect of mobility on neighborhood characteristics. The nearly universal welfare reduction for neighborhood 1 households can be thought of as a commitment problem. Under segregation, high human capital residents of neighborhood 1 are forced to stay. Once segregation is lifted, these households can no longer commit not to move. Although they may be better off if they could agree to remain in their neighborhood, the lack of commitment makes collusion impossible.[14] Anticipating the future deterioration of their neighborhood, high human

[13] It should again be stressed that the model is a parsimonious representation of neighborhood sorting and externalities; these welfare calculations are not normative statements about the history of racial integration in the US.

[14] Because removing segregation allows neighborhood 2 residents to move as well, it is not clear that high human capital neighborhood 1 households will be better off from colluding. If collusion was sustained, then neighborhood 1

capital agents flee to neighborhood 2, accepting high house prices as a result.

One way to quantify the relative importance of the factors driving these welfare results is to simulate counterfactual scenarios. We proceed by simulating zero-measure agents for whom we externally set preferences so as to place no utility weight on housing (ie, $\theta = 0$).[15] The welfare difference between these zero-measure agents and the agents in the model arises entirely from the movement in house prices. Figure 9a plots the consumption compensation for both the model agents and the zero-measure agents who begin transition in neighborhood 1. As mentioned above, the welfare impact is quite negative for nearly all model households. While households in low human capital states of the world would enjoy large welfare gains from mobility, no household in the model ever visits these states. Zero-measure agents greatly prefer mobility to segregation since it allows them access to better technology and a larger externality at no cost. Thus, the negative welfare impact for neighborhood 1 households in the model is due to the large increase in the house price that these agents must pay to live in neighborhood 2.

We repeat this exercise for households starting in neighborhood 2. The results are shown in Figure 9b. As expected, welfare is reduced for both model households and zero-measure households because migration reduces average human capital in their neighborhood. Model households suffer an additional welfare reduction from the increase in their house price. Note that this change is much smaller than for their neighborhood 1 counterparts. Since the original house price in neighborhood 2 was already high the relative price increase for these households is much smaller than for those moving from neighborhood 1.

4 Conclusion

This paper examined the effects of neighborhood externalities and mobility on income using a dynamic overlapping-generations model calibrated to match data from Chicago in 1960. Removing restrictions on neighborhood choice leads to a migration of residents from the low human capital neighborhood into the high human capital neighborhood. In the long run, all households move into the high human capital neighborhood, however over the transition high income households make the move first. A dynamic like that described by Wilson (1987) occurs wherein the erosion of human capital in the poorer neighborhood makes it more expensive for the remaining households to increase their human wealth, leading to concentrated poverty. On average, welfare is reduced from opening to sorting. Moreover, the welfare decline is largest for households in the poor neighborhood in the initial steady state. This is due both to the prolonged time some of these households remain in the deteriorating neighborhood and to the sharp increase in per unit housing cost paid once they move out. Comparing the transition path to the data for Chicago from 1960-1990, we find that the model captures the qualitative aspects of income, although the speed of transition in the model is higher than in the data.

would appear more attractive to neighborhood 2 households. If population flows into neighborhood 1, house prices will rise.

[15] We also simulate zero-measure agents who place no weight on housing and who additionally always earn the wage from the initial steady state. The general equilibrium wage effect is negative, but small. We omit the results for these agents since they look almost identical to those for our counterfactual zero-measure agents who receive the equilibrium wage.

References

Aiyagari, S. R. (1994). Uninsured idiosyncratic risk and aggregate saving. *The Quarterly Journal of Economics 109*(3), 659–684.

Aliprantis, D. (2012). Assessing the evidence on neighborhood effects from Moving to Opportunity. *Federal Reserve Bank of Cleveland Working Paper 11-22R*.

Badel, A. (2010). Understanding permanent black-white earnings inequality. *Federal Reserve Bank of St. Louis Working Paper 2010-047B*.

Bayer, P., H. Fang, and R. McMillan (2011). Separate when equal? Racial inequality and residential segregation. *Mimeo., University of Pennsylvania*.

Bayer, P., F. Ferreira, and R. McMillan (2007). A unified framework for measuring preferences for schools and neighborhoods. *Journal of Political Economy 115*(4), 588–638.

Bénabou, R. (1993). Workings of a city: Location, education, and production. *The Quarterly Journal of Economics 108*(3), pp. 619–652.

Bénabou, R. (1996). Heterogeneity, stratification, and growth: Macroeconomic implications of community structure and school finance. *The American Economic Review 86*(3), pp. 584–609.

Bertrand, M. and S. Mullainathan (2004). Are Emily and Greg more employable than Lakisha and Jamal? A field experiment on labor market discrimination. *The American Economic Review 94*(4), 991–1013.

Bewley, T. F. (1986). *Contributions to Mathematical Economics in Honor of Gerard Debreu*, Chapter Stationary Monetary Equilibrium with a Continuum of Independently Fluctuating Consumers, pp. 79–102. Amsterdam: North Holland.

Blackmon, D. A. (2008). *Slavery by Another Name: The Re-enslavement of Black People in America from the Civil War to World War II*. Doubleday.

Borjas, G. J. (1995). Ethnicity, neighborhoods, and human-capital externalities. *The American Economic Review 85*(3), pp. 365–390.

Boustan, L. P. (2010). Was postwar suburbanization "white flight"? Evidence from the black migration. *The Quarterly Journal of Economics 125*(1), 417–443.

Boustan, L. P. (2011). School desegregation and urban change: Evidence from city boundaries. *American Economic Journal: Applied Economics*. Forthcoming.

Bowles, S., G. C. Loury, and R. Sethi (2009). Group inequality. *Mimeo., Columbia University*.

Carneiro, P., J. J. Heckman, and D. V. Masterov (2005). Labor market discrimination and racial differences in premarket factors. *Journal of Law and Economics 48*, 1–39.

Cutler, D. M., E. Glaeser, and J. L. Vigdor (1999). The rise and decline of the American ghetto. *Journal of Political Economy 107*(3), 455–506.

Cutler, D. M. and E. L. Glaeser (1997). Are ghettos good or bad? *Quarterly Journal of Economics 112*(·), 827–872.

Douglass, F. (1982). *Narrative of the Life of Frederick Douglass, an American Slave*. Penguin.

Durlauf, S. N. (1996). A theory of persistent income inequality. *Journal of Economic Growth 1*(1), 75–94.

Epple, D. and R. E. Romano (1998). Competition between private and public schools, vouchers, and peer-group effects. *The American Economic Review 88*(1), pp. 33–62.

Fang, H. and G. C. Loury (2005). Toward an economic theory of dysfunctional identity. In C. B. Barrett (Ed.), *Social Economics of Poverty: On Identities, Groups, Communities and Networks*, pp. 12–55. Routledge.

Fang, H. and A. Moro (2010). Theories of statistical discrimination and affirmative action: A survey. *NBER Working Paper 15860*.

Fernandez, R. and R. Rogerson (1998). Public education and income distribution: A dynamic quantitative evaluation of education-finance reform. *The American Economic Review 88*(4), pp. 813–833.

Glomm, G. and B. Ravikumar (1992). Public versus private investment in human capital: Endogenous growth and income inequality. *Journal of Political Economy 100*(4), pp. 818–834.

Goldberger, A. S. and C. F. Manski (1995). Review article: *The Bell Curve* by Herrnstein and Murray. *Journal of Economic Literature 33*(1), 762–776.

Guerrieri, V., D. Hartley, and E. Hurst (2012). Endogenous gentrification and housing price dynamics. *Federal Reserve Bank of Cleveland Working Paper 10-08R*.

Hanushek, E. A. and S. G. Rivkin (2006). School quality and the black-white achievement gap. *NBER Working Paper 12651*.

Ioannides, Y. M. (2010). Neighborhood effects and housing. In J. Benhabib, A. Bisin, and M. O. Jackson (Eds.), *Handbook of Social Economics*, pp. Forthcoming. Elsevier.

Kremer, M. (1997). How much does sorting increase inequality? *The Quarterly Journal of Economics 112*(1), 115–139.

Lucas, Jr., R. E. (1987). *Models of Business Cycles*. New York: Basil Blackwell.

Lundberg, S. and R. Startz (1998). On the persistence of racial inequality. *Journal of Labor Economics 16*(2), 292–323.

Margo, R. A. (1990). *Race and Schooling in the South: 1880-1950*. University of Chicago Press.

Massey, D. and N. Denton (1993). *American Apartheid: Segregation and the Making of the Underclass*. Cambridge: Harvard University Press.

Meyer, S. G. (2000). *As Long as They Don't Move Next Door: Segregation and Racial Conflict in American Neighborhoods*. Rowman & Littlefield.

Minnesota Population Center (2004). *National Historical Geographic Information System* (Prerelease Version 0.1 ed.). Minneapolis, MN: University of Minnesota. http://www.nhgis.org.

Naidu, S. (2010a). Recruitment restrictions and labor markets: Evidence from the post-bellum US South. *Journal of Labor Economics 28*(2), 413–445.

Naidu, S. (2010b). Suffrage, schooling, and sorting in the post-bellum US South. *Mimeo., Columbia University*.

Neal, D. A. and W. R. Johnson (1996). The role of premarket factors in black-white wage differences. *Journal of Political Economy 104*(5), 869–895.

Polikoff, A. (2006). *Waiting for Gautreaux*. Northwestern University Press.

Sampson, R. J., J. D. Morenoff, and T. Gannon-Rowley (2002). Assessing "neighborhood effects": Social processes and new directions in research. *Annual Review of Sociology 28*, pp. 443–478.

Williams, H. A. (2007). *Self-Taught: African American Education in Slavery and Freedom*. University of North Carolina Press.

Wilson, W. J. (1987). *The Truly Disadvantaged: The Inner City, the Underclass, and Public Policy*. University of Chicago.

Zuberi, T. (2001). *Thicker Than Blood: How Racial Statistics Lie*. University of Minnesota Press.

5 Appendix A: Segregation and Discrimination

5.1 A Brief History of Racial Segregation in US Cities

The historical evidence indicates that the black ghetto in the US was born between 1890 and 1940 and grew between 1940 and 1970. Cutler et al. (1999) find these historical periods, along with one of falling segregation between 1970 and 1990, using decennial census data to measure within-city segregation between 1890 and 1990. Summarizing the overall trends during these periods, Cutler et al. (1999) find that the average urban black lived in a neighborhood that was 27 percent black in 1890, and estimate this grew to 43 and then 68 percent in 1940 and 1970, before declining to 56 percent in 1990.

Massey and Denton (1993) note that blacks and whites were not particularly segregated before 1900. This changed in the first decades of the 20th century in response to the Great Migration, in which large numbers of African Americans moved to Northern cities from the South. By 1930 the boundaries within which blacks were allowed to live in most urban areas in the US had been established through violence, collective anti-black action, racially restrictive covenants, and discriminatory real estate practices (Massey and Denton (1993)).[16] Extremely high demand for this limited supply of housing pushed whites out of neighborhoods designated to be black (Massey and Denton (1993)), leading to a level of segregation between blacks and whites by 1940 that no other minority group came remotely close to achieving.[17]

With the black ghetto growing in the decades after 1940, segregation was maintained as whites fled to the suburbs in response to black in-migration (Boustan (2010)) and school desegregation

[16] See Polikoff (2006) for a discussion of violence directed at blacks moving into white neighborhoods. Massey and Denton (1993) give examples of all of these practices; consider one example provided for discriminatory real estate practices: In 1924 National Association of Real Estate Brokers' code of ethics adopted the statement that "a Realtor should never be instrumental in introducing into a neighborhood... members of any race or nationality... whose presence will clearly be detrimental to property values in that neighborhood" (p 37).

[17] The gap between supply and demand was exasperated by a large migration of blacks from the South to Northern cities between 1930 and 1940 due to the Great Depression, together with a decline in housing construction due to the Great Depression and World War II (Massey and Denton (1993), pp 42-43).

(Boustan (2011)). Also contributing to the maintenance of segregation was an increase in the violence directed against blacks moving into white neighborhoods during the 1950s and 60s, especially in the North (Meyer (2000)).

5.2 Recent Data on Racial Segregation

Variables measuring the racial composition of census tracts enter our model through the definition of neighborhoods, and we use these variables and some related ones to look at residential segregation in the US and Chicago between 1960 and 1990. Figure 10 shows the variable used to fit the model to the data, the share of African American residents in a tract. In 1960 the median black in the US lived in a neighborhood that was 77 percent black, and this fell to 53 percent by 1990.

However, the national pattern did not hold across all locations, and Chicago is a good city to illustrate this point. We see in Figure 10 that the black population in Chicago had two experiences between 1960 and 1990. One group of African Americans tended to live in more integrated neighborhoods, while another group of African Americans tended to live in even more segregated neighborhoods. In other words, it became more likely that blacks lived in a neighborhood with a relative low share of blacks, but it also became more likely that blacks lived in a neighborhood with an extremely high share of blacks. It is important to note that the share of blacks living in very segregated neighborhoods is very large. Consider that in 1960 the median black person in Chicago lived in a neighborhood that was 95 percent black, and that by 1990 this actually increased to 98 percent.

We define neighborhood 1 in 1960 as all census tracts in which 80 percent or more of the residents were black, and under this definition a full 75 percent of African Americans in Chicago lived in neighborhood 1 in 1960. The percentage of African Americans living in the geographic boundaries defined by neighborhood 1 dropped to 21 percent by 1990, but the percentage of African Americans living in a neighborhood in which 80 percent or more of the residents were black dropped only to 67 percent by 1990. Figure 4 shows these census tracts on maps. We see that segregated areas grew spatially quite substantially between 1960 and 1990, with much of that growth occurring in tracts directly neighboring neighborhood 1. We also see an increase in census tracts in neighborhood 2 with larger shares of African Americans, between 40 and 80 percent. It should be noted that these tracts in neighborhood 2 tend to be the ones closest to neighborhood 1, and are probably the higher human capital, segregated neighborhoods documented in Bayer et al. (2011). By 1990 there are likely to be large qualitative differences between racially-segregated, majority-black neighborhoods.

In order to compare the experiences of African Americans to those of other minority groups, we can also look at the share of whites in a given census tract. These data are shown in Figure 11, and they are another way of showing that the majority of African Americans in Chicago lived in extreme segregation both in 1960 and in 1990. The median black person in Chicago lived in a neighborhood that was 4 percent white in 1960 and 2 percent white in 1990. This extreme racial segregation strongly contrasts with the experiences of other minority groups, of which only a very tiny share live in neighborhoods so devoid of whites. For other minorities the median person in Chicago lived in a neighborhood that was 95 percent white in 1960 and 65 percent white in 1990. As discussed in Massey and Denton (1993), these figures confirm that the segregation experienced in African American neighborhoods is unlike that of the immigrant enclaves experienced by other minority groups.

5.3 Racial Discrimination

Segregation would not be a problem if blacks and whites lived in separate but equal neighborhoods, and could possibly even be a good thing (Cutler and Glaeser (1997), Borjas (1995)). The racial discrimination experienced by blacks makes this scenario highly unlikely.

Consider first the impact of racial discrimination on blacks' pre-market experiences. The white fear of black education that inspired antiliteracy laws during the Antebellum Period (Douglass (1982)) expressed itself during Reconstruction in the form of violence against blacks who sought educational instruction (Williams (2007)). Disenfranchisement had negative effects on black school quality in the Post-Bellum South (Naidu (2010b), Margo (1990)), and still today school quality can explain much of the racial gap in achievement (Hanushek and Rivkin (2006)).

Blacks have also experienced discrimination once in the labor market. Amongst the legislation that benefited white employers at the expense of black workers (Naidu (2010a)), recent research has shown that spurious laws were widely used to re-enslave blacks between the Emancipation Proclamation and World War II (Blackmon (2008)). And even if its importance has declined relative to the role of pre-market factors in determining labor market outcomes today (Neal and Johnson (1996), Carneiro et al. (2005)), discrimination still plays a role in current labor market outcomes (Bertrand and Mullainathan (2004)).

6 Appendix B: Computational Algorithm

6.1 Calibration to SRCE Steady State

Outer loop:

I. Guess parameter vector x^0.

Inner loop:

1. Use a coarse grid over h_{coarse} of 1000 points and an a-grid of 9 points. From h_{course} construct a refined grid h_{fine} of 5000 points.

2. Population shares ψ_1 and ψ_2 are fixed. Guess $p_1^0, p_2^0, H_1^0, H_2^0, \Gamma_1^0(h_{fine}, a)$, $\Gamma_2^0(h_{fine}, a)$, and $V^0(h_{coarse}, a)$.

3. $w = \alpha\left(\psi_1 H_1^0 + \psi_2 H_2^0\right)^{\alpha-1}$.

4. Solve the Bellman equation using cubic splines to interpolate over V^0. This yields decision rules $g(h_{coarse}, a) = \{g_c(h_{coarse}, a), g_i(h_{coarse}, a), g_s(h_{coarse}, a)\}$ and a new value function $V^1(h_{coarse}, a)$.

5. Linearly interpolate over g to get $\tilde{g}(h_{fine}, a)$.

6. Beginning with Γ_1^0, and Γ_2^0. Use $\tilde{g}$ to produce Γ_1^1, Γ_2^1. Continue iterating unitl $\left\|\Gamma_1^n - \Gamma_1^{n+1}\right\|^\infty < \varepsilon_\Gamma$ and $\left\|\Gamma_2^n - \Gamma_2^{n+1}\right\|^\infty < \varepsilon_\Gamma$ for some small ε_Γ.

7. Calculate $\hat{S}_1$, $\hat{S}_2$, $\hat{H}_1$, $\hat{H}_2$. For $k = 1, 2$, find the implied market clearing house price.

$$\hat{p}_k = \frac{w}{\alpha}\left(\hat{S}_k\right)^{\frac{\alpha-1}{\alpha}}.$$

8. Update price guesses: $p_k^1 = \zeta_p \hat{p}_k + (1-\zeta_p)\, p_k^0,\ \zeta_p \in (0,1)$. Repeat steps $4-8$ until $\left\|p_1^n - p_1^{n+1}\right\|^\infty < \varepsilon_p$ and $\left\|p_2^n - p_2^{n+1}\right\|^\infty < \varepsilon_p$. Then go to 9.

9. Update per capita human capital guesses: $H_k^1 = \zeta_H \hat{H}_k + (1-\zeta_H)\, H_k^0,\ \zeta_H \in (0,1)$. Repeat steps $3-9$ until $\left\|H_1^n - H_1^{n+1}\right\|^\infty < \varepsilon_H$ and $\left\|H_2^n - H_2^{n+1}\right\|^\infty < \varepsilon_H$. Then go to 10.

10. Calculate the sum of squared errors from the differences between data statistics and those implied by $\tilde{g}$, Γ_1, and Γ_2 at x_0.

End of Inner Loop

II Use Nelder-Mead to minimize sum of square errors.

6.2 Transition to MRCE Steady State from Initial SRCE Steady State

I. Find new steady state by following steps 1-9 above. Because ψ_1 and ψ_2 can change, guess w^0, along with $p_1^0, p_2^0, H_1^0, H_2^0$. Update w in an analogous manner as H_k.

II.

1. To find the transition path, assume that a steady state it reached in $T+1$ periods.

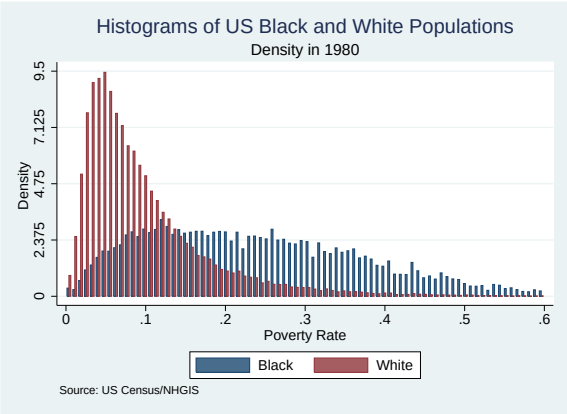
   Guess a sequence house prices, wages, and per capita human capitals from period 0 to T. Beginning at period T and using the continuation value found in step 1, solve the household problem backward, storing the decision rules and value function along the way and using the $t+1$ continuation value to solve the household problem at t.

2. Simulate forward to period T starting using the decision rules found in step 3, starting with the initial distributions Γ_1, Γ_2 found in the calibration above. Calculate the implied prices, wages, and per capita human capital levels during the simulation.

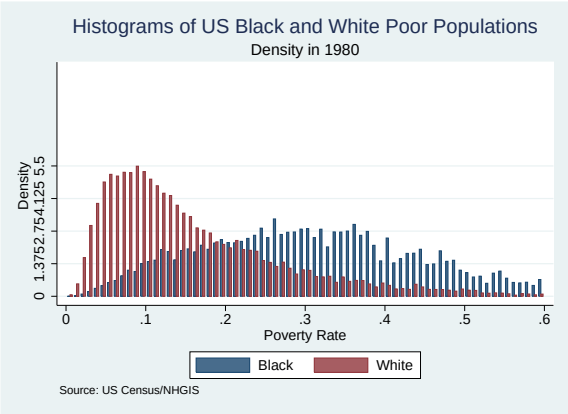
3. Update the transition path guess as a linear combination of the initial guess and the implied value.

4. Repeat 1-3 until the maximum difference between the transition path guess and the implied value in any period is less than some small tolerance.

Figures

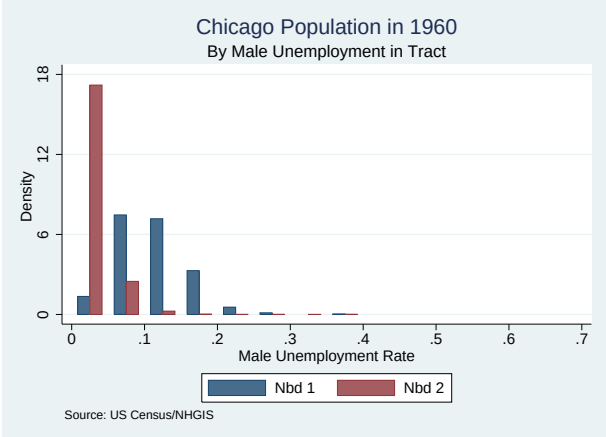


(a) The Black and White Populations in 1980

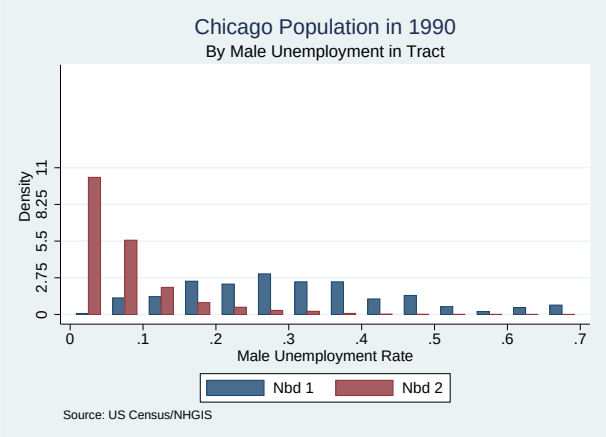


(b) The Black and White Poor in 1980

Figure 1: Distribution by Neighborhood Poverty in 1980



(a) 1960



(b) 1990

Figure 2: Male Unemployment Rate

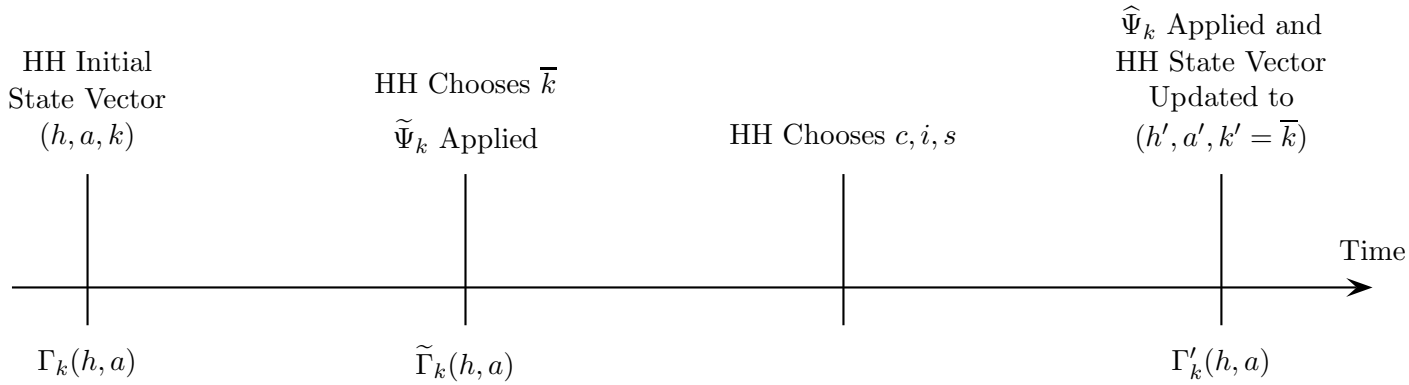
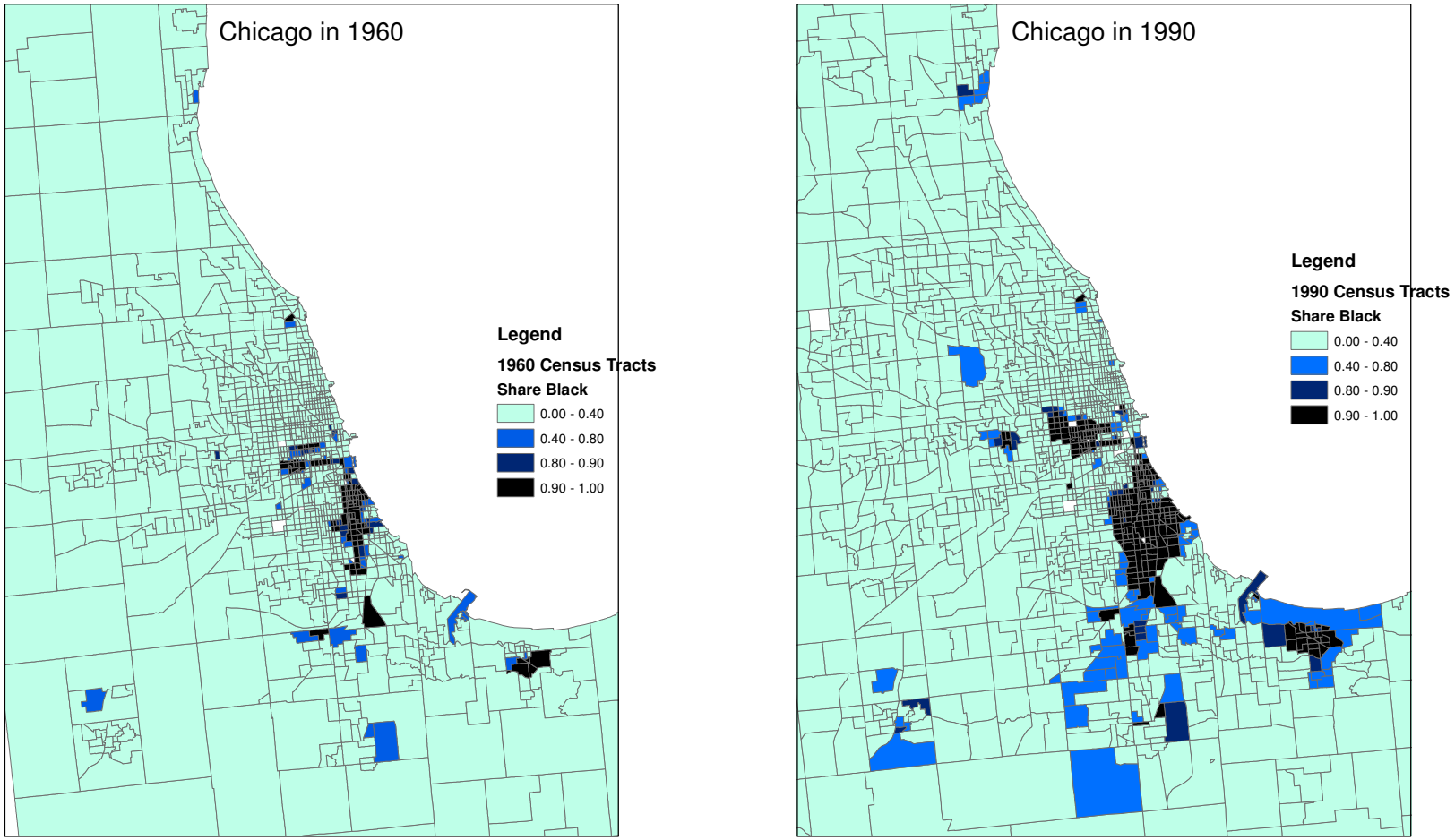


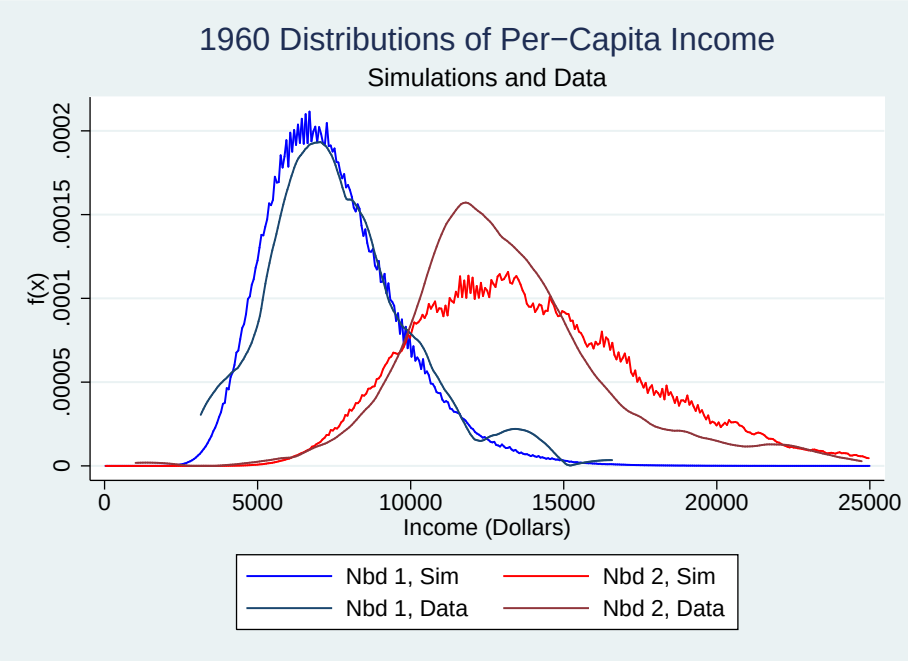
Figure 3: Timeline of Household Choices and Evolution of Distributions and State Vector



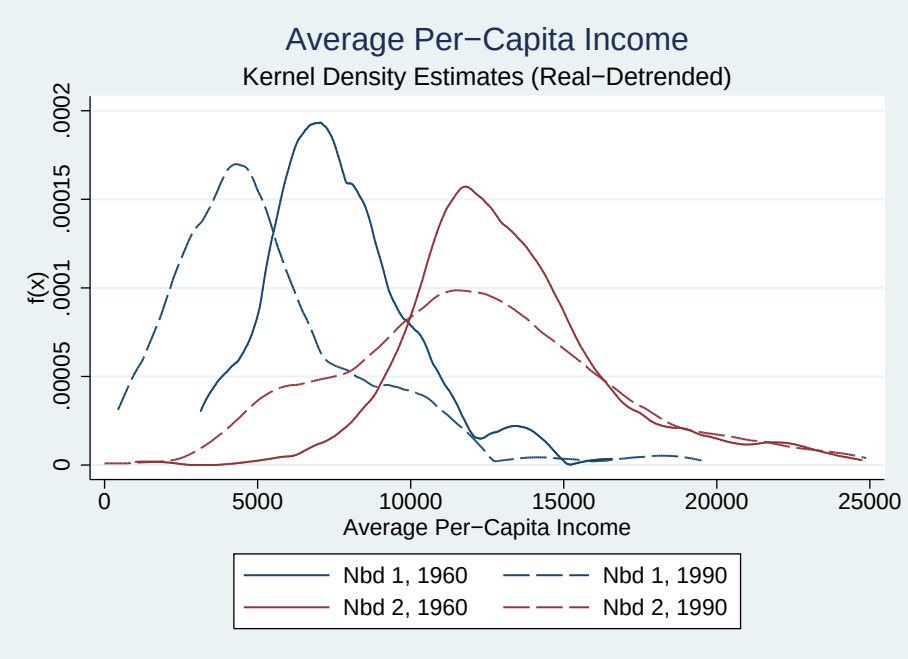
(a) 1960

(b) 1990

Figure 4: Racial Composition of Neighborhoods in Chicago

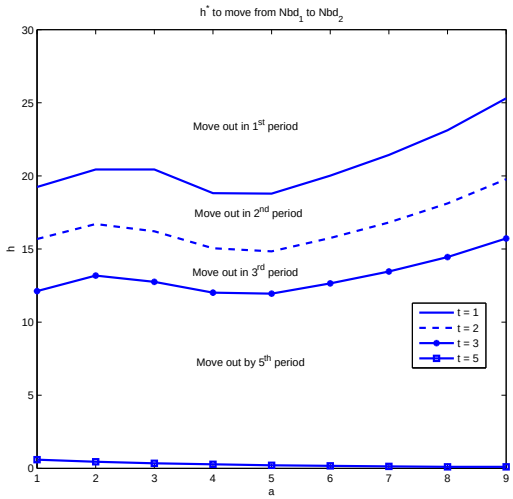


(a) 1960 Data and Model Steady State

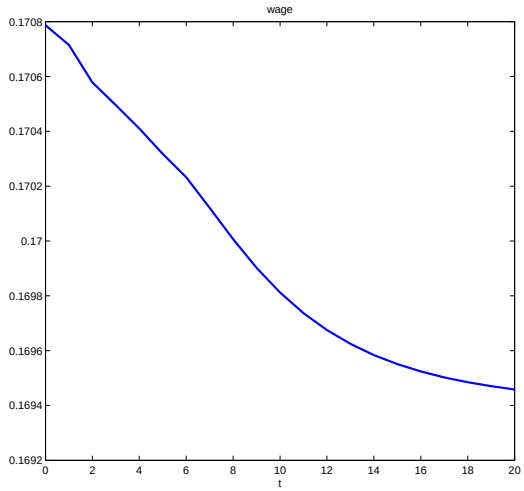


(b) 1960 and 1990 Data

Figure 5: Income Distributions by Neighborhood

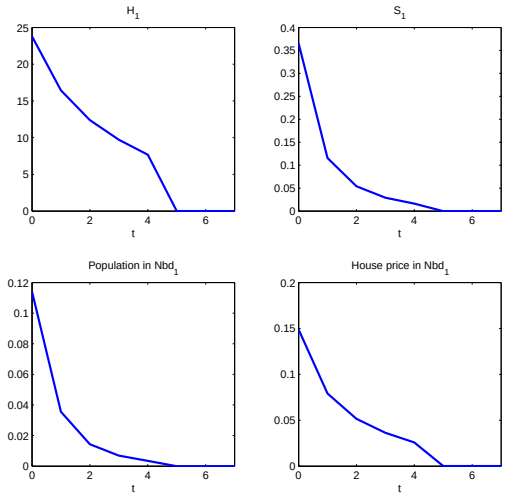


(a) Moving Conditional on State Space

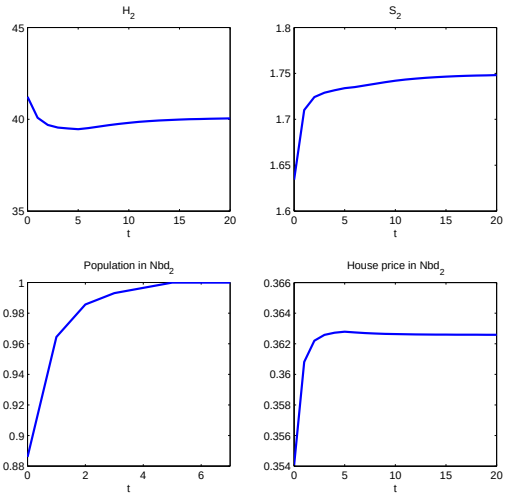


(b) Wage over Time

Figure 6: Transition Dynamics

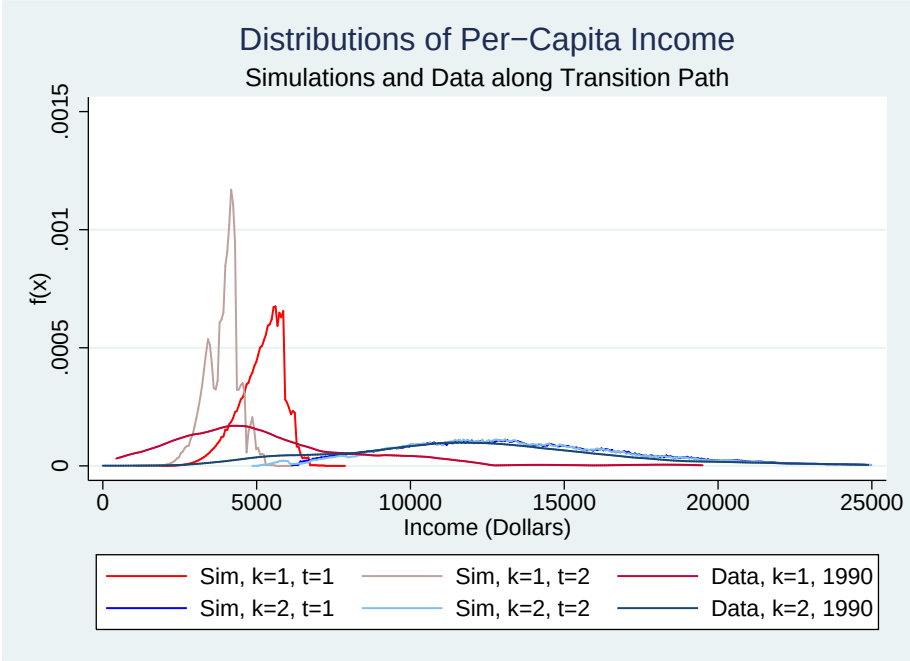


(a) Neighborhood 1

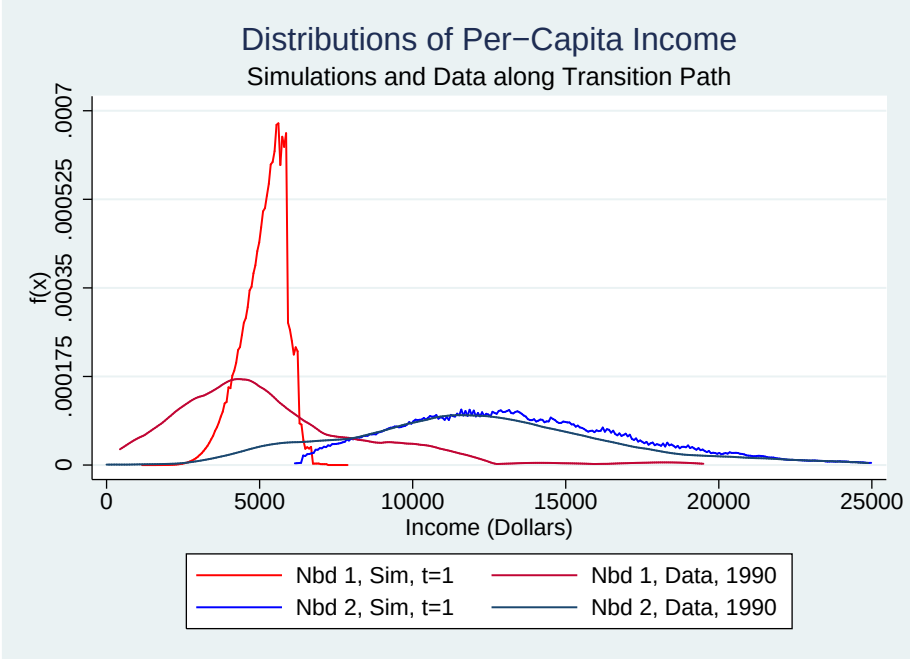


(b) Neighborhood 2

Figure 7: Transition Dynamics

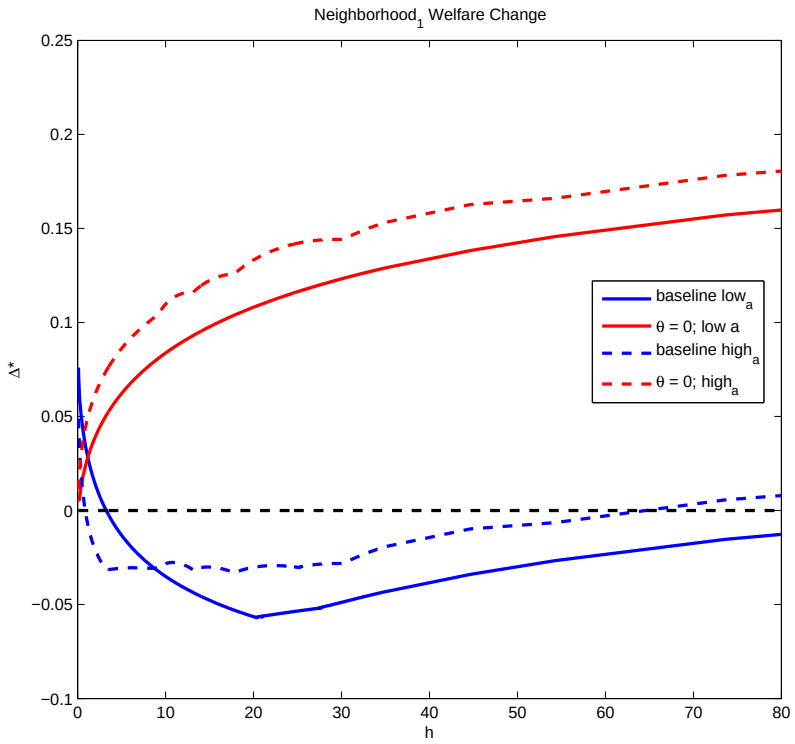


(a) The Transition (Data: 1990, Model: $t = 1, 2$)

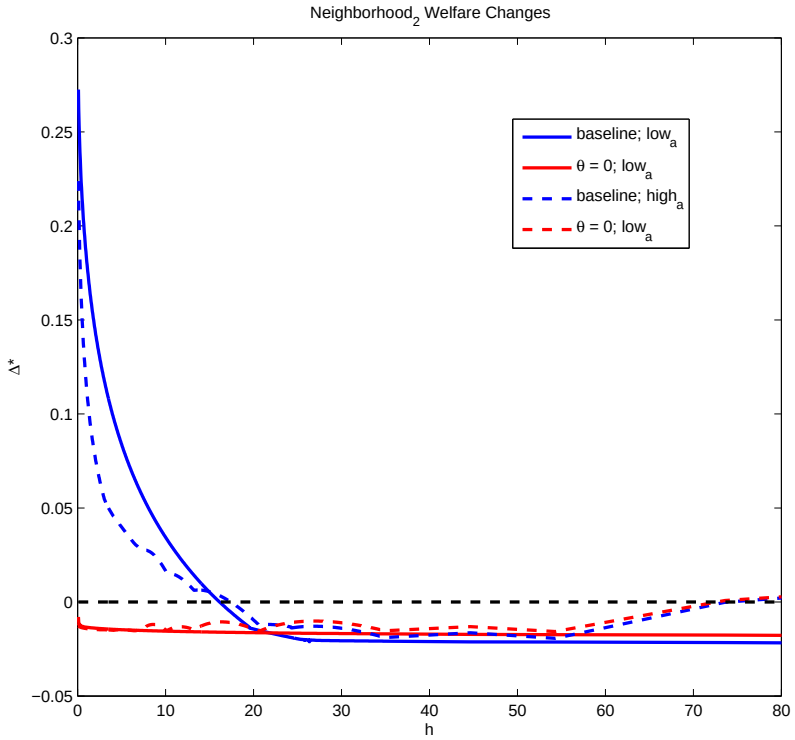


(b) The Transition (Data: 1990, Model: $t = 1$)

Figure 8: The Transition Path

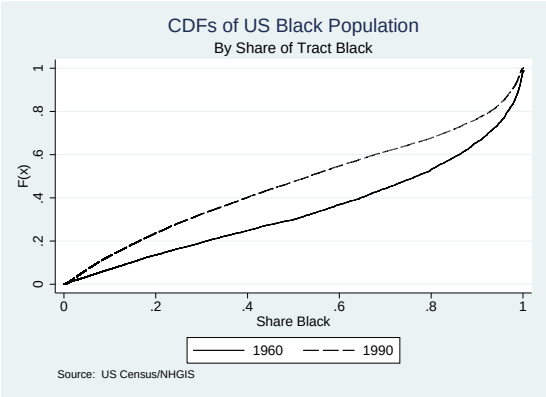


(a) Δ^* as a Function of h (Neighborhood 1)

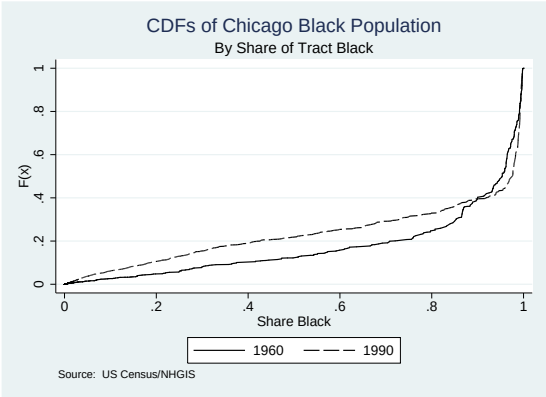


(b) Δ^* as a Function of h (Neighborhood 2)

Figure 9: Welfare Change as a Function of Human Capital Level when $\theta = 0$

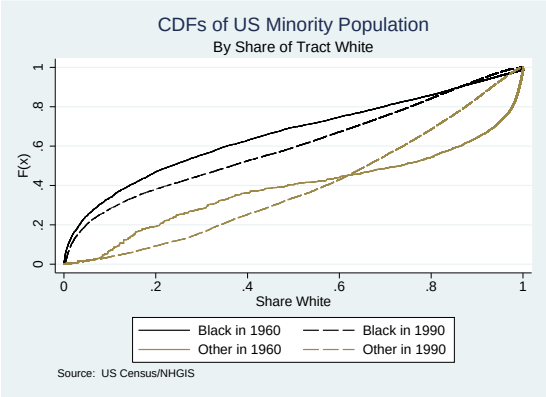


(a) Blacks in US

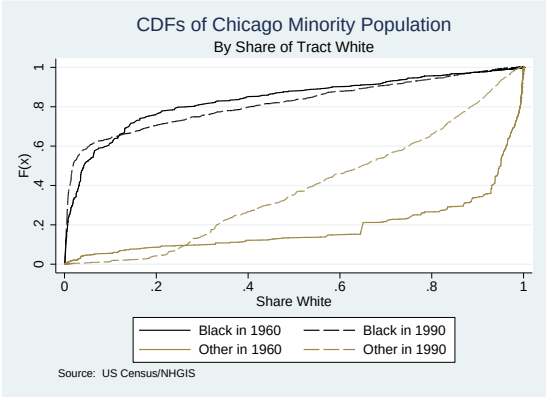


(b) Blacks in Chicago

Figure 10: Segregation of African Americans in the US and Chicago in 1960 and 1990



(a) Minorities in US



(b) Minorities in Chicago

Figure 11: Segregation of Minorities in the US and Chicago in 1960 and 1990

Tables

Table 1: Model Parameters

Parameter Description	Parameter	Value	Identification
Persistence of human capital	$(1-\delta)$	0	Set by Authors
Labor share	α	0.64	Set by Authors
Housing/Cons. Preference	θ	0.166	Eq. Condition, 1960 NIPA Data
Altruism and Time Preference	β	0.517	Calibrated, 1960 Census Data
Production function	λ_1	0.305	Calibrated, 1960 Census Data
Production function	λ_2	0.299	Calibrated, 1960 Census Data
Production function	γ	–0.680	Calibrated, 1960 Census Data
Ability process	σ_a	0.232	Calibrated, 1960 Census Data
Ability process	ρ	0.056	Calibrated, 1960 Census Data

Table 2: Moments Used to Calibrate the Model

Moment	Data 1960	Model Steady State
$c/(wh)$ in Nbd 2	0.63	0.52
H_1/H_2	0.56	0.58
$[Q_{H_1}(0.75) - Q_{H_1}(0.25)]/[Q_{H_2}(0.75) - Q_{H_2}(0.25)]$	0.70	0.61
$[Q_{H_2}(0.75) - Q_{H_2}(0.50)]/[Q_{H_2}(0.50) - Q_{H_2}(0.25)]$	1.35	1.21
$Q_{H_1}(0.90)/Q_{H_1}(0.10)$	2.19	2.05
$Q_{H_2}(0.90)/Q_{H_2}(0.10)$	1.88	2.07

Table 3: Human Capital and Population Shares in the Data over Time

	Data			
	1960	1970	1980	1990
H_1/H_2	0.56	0.54	0.49	0.41
Percent of Overall Pop in Nbd 1	11.4	8.3	5.8	4.1
Percent of Black Pop in Nbd 1	75.3	46.1	28.9	21.5

Table 4: Human Capital and Population Shares Implied by the Model over Time

	Model			
	t=0	t=1	t=2	t=3
H_1/H_2	0.58	0.41	0.25	0.19
Percent of Overall Pop in Nbd 1	11.4	3.6	0.7	0.1

Table 5: The Distribution of Human Capital in the Initial Steady State

	Percentile of Human Capital Distribution								
	Min	1%	10%	25%	50%	75%	90%	99%	Max
Nbd 1	3.7	9.2	15.7	18.7	22.8	27.6	32.7	43.7	102.1
Nbd 2	6.1	20.3	27.5	32.8	39.7	48.0	56.8	75.9	186.7

Table 6: Average Percent Welfare Change (Δ^*) by Ability (a)

	Ability (a)								
	0.35	0.48	0.62	0.79	1.0	1.27	1.62	2.1	2.84
Nbd 1	−31.1	−5.1	−5.2	−5.1	−4.9	−4.5	−4.0	−3.5	−2.8
Nbd 2	−1.7	−2.1	−2.1	−2.0	−1.9	−1.8	−1.7	−1.6	−1.6