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A Racial Inequality Trap

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Abstract

Why has the U.S. black/white earnings gap remained around 40 percent for nearly 40 years? This paper's answer consists of a model of skill accumulation and neighborhood formation featuring a trap: Initial racial inequality and racial preferences induce racial segregation and asymmetric skill accumulation choices that perpetuate racial inequality. Calibrated to match the U.S. distribution of race, house prices and earnings across neighborhoods, the model produces one-half of the observed racial earnings gap. Moving the economy from the trap to a racially integrated steady state implies a 15.6 percent welfare gain for black households and a 2.7 percent loss for white households.

JEL Classification: E24, J15, J24, O18.

Keywords: Racial Inequality, Neighborhood Externalities, Human Capital, Segregation, Incomplete Markets, Earnings Inequality.

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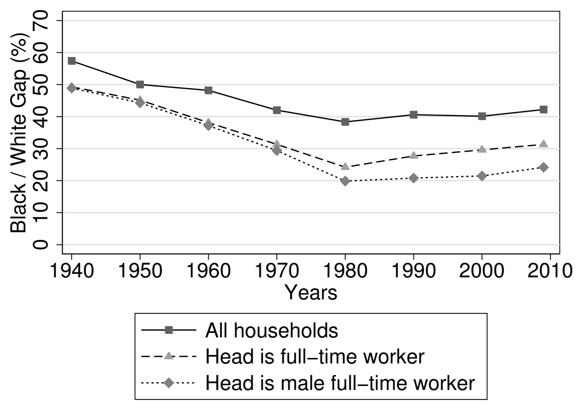
Introduction

The black/white earnings gap has remained near 40 percent since 1970, suggesting black/white earnings inequality can be currently viewed as permanent.[1] This fact is illustrated by the solid line in Figure 1.[2] This paper provides a dynastic human capital model where racial inequality and racial residential segregation can persist indefinitely. The model can go a long way toward quantitatively understanding these phenomena.

Figure 1: Black/white average household earnings gap



Based on decennial Census (1940 - 2000) and American Community Survey (2009) data. The sample includes single-family households headed by a U.S.-born black or white person between 25 and 64 years of age. Household annual earnings are measured as earnings of the head of household plus spouse earnings (if present) divided by the adult equivalence scale $\sqrt{\#adults + 0.5 \times \#children}$. The gap is defined as the percentage difference between black and white average household earnings. The gap is plotted for three subsamples: all households, households headed by a full-time worker and households headed by a male full-time worker. Appendix A1 contains additional details.

Each generation of black and white households makes time investments in human capital for the next generation. Idiosyncratic learning ability shocks are autocorrelated and their distribution is identical across races. Each generation chooses their residential location from a menu of neighborhoods whose characteristics are determined by the location and housing demand decisions of all households. Steady states with racial earnings inequality are sustained by the combination of (i) residential sorting by human capital and learning ability, (ii) residential segregation by race and (iii) neighborhood externalities that enhance human capital accumulation. These externalities capture the better provision of public services (e.g. early and late education, recreational facilities, safety, air

[1] Throughout the paper a black/white gap in variable x is defined as $gap = 1 - x_{black}/x_{white}$

[2] The dotted lines in Figure 1 show that the gap is also large and persistent among households headed by either a full-time worker or a full-time male worker, suggesting that the gap is not easily explained by racial differences in labor force attachment or household composition.

quality, transportation etc.) and other neighborhood externalities (e.g. network effects or peer effects) that are proportional to the neighborhood's mean earnings.

Residential sorting by human capital arises because high human capital (high earnings) households are willing to accept higher housing prices to access high externalities. Racial segregation arises for two reasons. First, sorting by human capital induces some segregation by race when human capital and race are correlated. Second, preferences over the racial composition of neighborhoods, by which households prefer to live in areas with a high share of their own race, lead to further segregation. These racial preferences have been employed in both theoretical and applied work on residential segregation. Direct evidence is available from surveys that ask individuals to choose among visual representations of neighborhoods with various racial configurations (see the discussion in Sethi and Somanathan (2004) and references therein).

The equilibrium stationary distribution can feature lower mean human capital for black households because of an endogenous asymmetry in location choice. Because of preexisting black/white inequality, sorting by human capital implies some segregation by race such that black households are underrepresented in affluent neighborhoods. Racial preferences amplify this extent of racial segregation and cause the key asymmetry in location choice: Some black households choose to give up some of the positive neighborhood externalities in order to live in a neighborhood with a higher black population share (and locate in less affluent neighborhoods). While, in contrast, some white households give up cheaper housing in order to live in neighborhoods with a higher white share (and locate in more affluent neighborhoods).[3] Because of this asymmetry, some white children grow up in better neighborhoods than black children with identical learning ability and parental resources. This asymmetry perpetuates racial inequality. Without it, all dinasties revert to the mean at the same rate and the long-run black and white human capital distributions are identical.[4]

The model has multiple equilibria. An "integrated" steady state equilibrium is numerically approximated. In this integrated steady state, there is sorting by human capital, but there is full racial integration and no racial inequality. The existence of such integrated steady state leads to interpreting the steady state in the previous paragraph as a "racial inequality trap".

[3]Sethi and Somanathan (2004) explore the consequences of this type of tradeoff in a static sorting model where household income is exogenous.

[4]In many dynamic models, the distribution of capital is characterized by its global convergence to a unique stationary distribution. This is true in models with idiosyncratic fluctuations (e.g., Hugget, 1993 and Aiyagari 1994) and for the long-run distribution of aggregates in the stochastic one-sector growth model. This behavior implies that simply labeling a group of households as "white" and another group as "black" would lead to ongoing black/white convergence, regardless of the initial extent of black/white inequality.

A version of the model with two neighborhoods is calibrated to match the empirical pattern of earnings, race and house prices across U.S. residential areas; the value of parental time investments in children; and several features of the distribution of lifetime earnings. The model can reproduce these facts closely without relying on extreme parameter values or unusual functional forms.

The two-neighborhood characterization of the empirical patterns of earnings, race and house prices across U.S. residential areas is constructed by applying a clustering method to create two "representative neighborhoods" out of a sample of 17,082 neighborhoods from 30 large U.S. cities followed over the 1970-2000 period. This approach provides a simple construction with three main advantages. First, the two representative neighborhoods aggregate up to sample totals. Second, the characteristics of the two neighborhoods are roughly constant in the sample period and, third, the two-neighborhood characterization summarizes nearly 40 percent of the empirical variation of neighborhood earnings, racial composition and housing prices in the sample. The facts related to the distribution of lifetime earnings are based on earnings histories from the Panel Study of Income Dynamics (PSID), while the value of parental investments is calculated from time-use and wage data from the American Time Use Survey (ATUS).

The model reproduces some facts not targeted in the calibration. Most importantly, the steady-state black/white average earnings gap is 21 percent (i.e., 52 percent of the 40 percent gap shown in Figure 1). Also, the intergenerational earnings correlation and the intergenerational neighborhood-type correlation produced by the model agree closely with the data.[5] Finally, the magnitudes of neighborhood externalities and racial preferences at play in the model are not inconsistent with empirical estimates available in the literature.

The model, however, does not produce the full racial gaps in parental investments and earnings in the data. The unexplained component of these gaps reflects the model's abstraction from certain indirect factors that can amplify human capital differences (e.g., differences in leisure time, family composition, assortative matching, participation in welfare programs, participation in crime or incarceration) and also from direct factors impacting human capital and earnings such as racial discrimination and cultural differences.

Even though racial inequality is perpetuated by households' own racial preferences there can be large long-run welfare benefits of racial integration. Compared to the racially integrated steady state (where there is no black/white inequality), the inequality

[5] The empirical neighborhood-type intergenerational correlation is obtained by merging geographically coded PSID data with the representative-neighborhood classification described above. The merged data allows comparing the neighborhood where a PSID individual lived during childhood with the neighborhood where the individual lived as an adult.

trap steady state implies a consumption-equivalent welfare gain of 15.6 percent for black households, a 2.7 percent loss for white households and a 1.6 percent overall gain.

Also, size is crucial for the success of human capital policies in reducing black/white inequality.[6] If the policy is not extensive enough to alter the macroeconomic context (understood as the configuration of average earnings, racial composition and house prices across neighborhoods), the location decisions of households undo the equalizing effect of the policy within just a few generations: 51.3 percent of the effect of an ideal policy endowing black households with the white distribution of human capital disappears by the second generation and 88 percent disappears by the fourth generation.

The remainder of the paper proceeds as follows. Section 1 discusses related literature. Sectin 2 describes the model. Section 3 illustrates the mechanism using numerical decision rules from three versions of the model. Section 4 describes the calibration and empirical assessment. Section 5 introduces a racially integrated steady state of the model and discusses the inequality trap view of U.S. black/white earnings inequality. Section 6 discusses the importance of considering the macro context for interpreting human capital policies. The last section concludes.

1 Related Literature

This paper is related to at least four strands of the literature in economics. First, a literature that analyzes the effects of segregation on racial (or group-level) inequality. Prominently, Loury (1976) analyzes a model in which segregation and externalities produce group-level inequality, but the extent of segregation is exogenously specified.[7]

Second, the literature on residential segregation with exogenous income distribution. Schelling (1971) and Sethi and Somanathan (2004) provide models of segregation based on racial preferences.[8]

Third, the local public finance literature where the distribution of income is endogenous but race is abstracted from. Benabou (1993) and Durlauf (1996) provide multi-community models with endogenous distributions of income, while Fernandez and Rogerson (1998) provide a quantitative analysis of school finance reform. The model in this paper differs from Fernandez and Rogerson (1998) in three main ways. First, race is considered here. Second, investments in children are motivated by perfect altruism (instead

[6]See Carneiro and Heckman (2003) for a survey of human capital policies.

[7]See Lundberg and Startz (1998) and Bowles, Loury and Sethi (2008) for a similar approach.

[8]See also Bayer, McMillan and Reuben (2004), Bayer, Ferreira and McMillan (2007) and Bayer et al. (2010) for empirical applications based on exogenous earnings distributions.

of direct preferences over children's education).[9] Third, public choices over local expenditures (e.g. voting) are not modeled explicitly to maintain computational tractability.

Finally, this paper is also related to existing quantitative analyses of racial discrimination in the labor market. Bowlus and Eckstein (2002) introduce employers with racial preferences (Becker, 1957) in an environment with search frictions while Moro (2003) considers informational frictions that lead to statistical discrimination and multiple equilibria (Arrow, 1973 and Coate and Loury, 1993).[10]

2 The Model

Consider a unit continuum of dynastic households of which a fraction χ_B is black and a fraction $1-\chi_B$ is white. Time is discrete and at each period every household is composed of an adult and a child. A household is described by the vector $s=(h,r,z)$, where $h\in[0,\infty)$ is the adult's stock of human capital, $r\in\{B,W\}$ denotes race and $z\in Z\equiv\{z_1,z_2,z_3,...,z_K\}$ is the child's innate learning ability.

Every period, the household chooses a neighborhood $n\in\{1,2,3,...,N\}$, the fraction of parental time invested in child fostering $l\in[0,1]$, and how to allocate labor earnings into consuming housing services, g, and consuming other goods, c.

Households derive utility from consumption and from the fraction of their neighborhood's population that has their own race. Period utility is therefore denoted

$$u\left(c,g,\phi(R_n,r)\right)$$

where R_n is the fraction of neighborhood residents that are *black* and function ϕ simply returns the fraction of neighborhood residents that have the *same race* as the household:[11]

$$\phi(R_n,r)=\begin{cases}R_n, & \text{if } r=B\\ 1-R_n, & \text{if } r=W.\end{cases}$$

There is perfect (forward) intergenerational altruism, so a household internalizes the discounted future utility of its child. The time discount factor is $0<\beta<1$. The

[9]Perfect altruism increases the computational burden but endogenizes the value human capital investments, which can vary by race.

[10]See Fang and Moro (2011) for a review of statistical discrimination models.

[11]Function u is continously differentiable and strictly concave, strictly increasing in c and g and satisfies $\lim_{x\to\infty}u=0$ and $\lim_{x\to 0}u=\infty$ for $x=c,g$. Function u also satisfies $u\left(c,g,0\right)<u\left(c,g,1\right)$ for any $c,g\geq 0$. Monotonicity in the third argument is not imposed, so households may prefer a neighborhood with some degree of integration over one with an overwhelming majority of their own color. In Sethi and Somanathan (2004) such "pro-integrationist" preferences are found to be important for the stability of racially integrated equilibria.

household can transfer resources to the future only by investing in the child's future human capital. The future stock of human capital of a child with learning ability z is $h' = F(z, hl, Y_n)$, where F is strictly increasing in all arguments. Parents can thus enhance the future human capital of their children by investing effective units of time hl and/or by locating themselves in a neighborhood where the average earnings of residents, Y_n, are high.[12]

The household's budget constraint equates expenditures to total labor earnings so that $c + P_n g = wh(1 - l)$, where w is the market rental rate paid for an effective unit of labor and P_n is the price of housing services in neighborhood n.

At the end of each period, the adult dies, the child becomes an adult and a new child is born. Innate learning ability follows a first-order Markov structure given by transition probabilities $\pi_{kk'}$ which denote the probability that child learning ability is $z_{k'}$ tomorrow given that it is z_k today.[13]

There is no physical capital in the model since the focus is on human capital differences across races. The aggregate production technology of goods is linear in aggregate effective labor. The market for effective units of labor is competitive, so the rental rate w is considered equal to the exogenous marginal productivity of effective labor and equal for both races. For simplicity, housing services are supplied by landlords outside the model according to the supply function $L_n(P_n)$. The aggregate resource feasibility constraint simply states that output is either consumed by households or paid to landlords in exchange for housing services.

The household's decision problem is described recursively. The optimal decisions of a household in state $s = (h, r, z)$ solve the following Bellman equation, taking $\{Y_n, R_n, P_n\}_{n=1}^{N}$

[12]The production function F is strictly concave, twice continuously differentiable and strictly increasing in each argument. Strict concavity implies decreasing returns to scale and guarantees that individual and aggregate human capital lie in the compact set $[0, \overline{h}]$. Where the maximum sustainable level of human capital solves $\overline{h} = F(\overline{z}, \overline{h}, \overline{h})$, $\overline{h} > 0$. This condition is usually important to guarantee the existence of a steady state.

[13]Child learning ability is observed before the household makes decisions, assuming ex-ante observation of ability is consistent with model periods representing several years of investment decisions and observation of the child's characteristics by parents. The theoretical literature contains examples of ex-ante and ex-post observation of ability. For the former, see Becker and Tomes (1986), for the latter see Loury (1981).

as given:

$$V(s) = \max_{n \in \{1,2,3,\ldots,N\}} V_n(s) \text{ with}$$
$$V_n(s) = \max_{c,g,l} u(c, g, \phi(R_n, r)) + \beta E[V(s')|z]$$
$$\text{subject to}$$
$$c + P_n g = wh(1-l)$$
$$h' = F(z, hl, Y_n), \quad r' = r, \quad z' \sim \pi(.|z) \text{ for all } n.$$

Function V returns the highest utility attainable across neighborhoods 1 to N by a household with characteristics s. Neighborhood-specific optimal values V_n are determined by the household's optimal choices of c, g and l, given the characteristics of each neighborhood n. A solution of the household's problem is a set of neighborhood-specific decision rules $(c(s,n)\ g(s,n)\ l(s,n))$; neighborhood value functions $\{V_n(s)\}_{n=1}^{N}$; and a value function $V(s)$ satisfying the Bellman equation.

The household's decision problem does not specify the location of a household which turns out to be indifferent between two or more neighborhoods. For this reason indifferent households are assumed to randomize their location choice. The location decision rule is thus a probability distribution over neighborhoods. A location decision rule $\eta(n|s)$ is consistent with a solution to the household's problem if it is a probability distribution over values of n conditional on s such that

$$\eta(n|s) = 0 \text{ if } V_n(s) < \max_{n \in \{1,2,3,\ldots,N\}} \{V_n(s)\},$$

so that households choose strictly dominated neighborhoods with zero probability.[14] The probabilities not specified by the household's decision problem are left to be pinned down by equilibrium restrictions.

The equilibrium concept employed combines the stationary equilibrium of the neoclassical growth model with incomplete markets and idiosyncratic shocks, also known as the Bewley-Huggett-Aiyagari model, and the residential sorting model where households trade off local public good provision against tax rates and/or house prices, also known as Tiebout sorting equilibrium. Households experience idiosyncratic fluctuations due to learning ability shocks, while the aggregate characteristics of neighborhoods and the cross-sectional distribution of human capital remain unchanged over time. In each

[14] Function η is a conditional probability distribution if $\eta(n|s) \in [0,1] \forall n, s$ and $\sum_n \eta(n|s) = 1 \forall s$.

period, households perceive some neighborhood characteristics, which they take as given and make their location decisions. These location decisions, in turn, determine the actual characteristics of neighborhoods. In equilibrium, the perceived and the implied neighborhood characteristics must be equal.

Some aggregate variables are now defined. These variables are averages or sums of individual level variables. The function $\mu((\mathcal{A}, z, r))$ appearing in these definitions is a probability measure giving the mass of households with race r, innate ability z and human capital in some set $\mathcal{A}$ (i.e., with $h \in \mathcal{A} \subset [0, \bar{h}]$). This distribution is determined in equilibrium. The decision-implied neighborhood average earnings, neighborhood racial configuration and demand of housing services are given by

$$\begin{aligned}
\widehat{Y}_n &\equiv \frac{E_\mu \left[whl(n,s)\eta\left(n|s\right)\right]}{E_\mu \left[\eta\left(n|s\right)\right]}, \\
\widehat{R}_n &\equiv \frac{E_\mu \left[\eta\left(n|s\right)|\, r = B\right]}{E_\mu \left[\eta\left(n|s\right)\right]}, \text{ and} \\
\widehat{D}_n &\equiv E_\mu \left[g(s,n)\eta(n|s)\right],
\end{aligned}$$

respectively, where E_μ denotes an expectation taken with respect to the cross-sectional distribution μ. The transition function $P((h, r, z), (\mathcal{A}, r, z'))$ gives the probability that a household with characteristics (h, z, r) in the current period has characteristics (h', r, z') next period such that $h' \in \mathcal{A}$.[15]

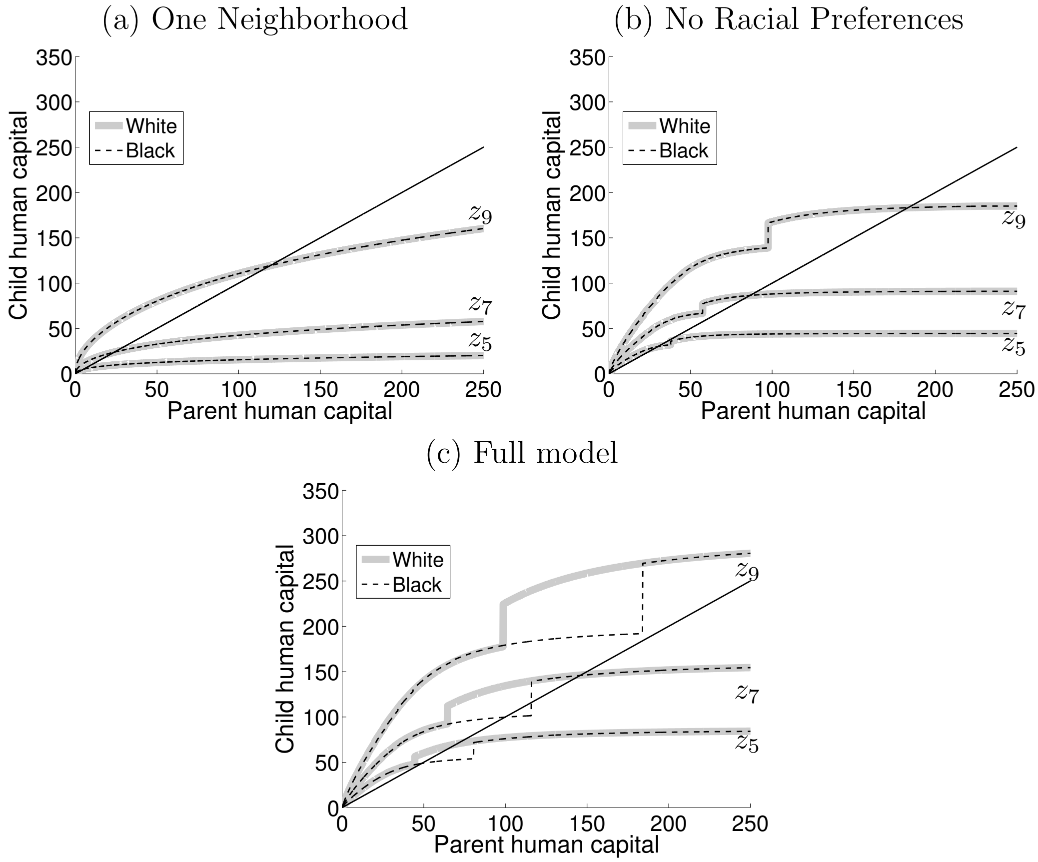
A recursive stationary equilibrium consists of a vector of neighborhood characteristics $\{(Y_n, R_n, P_n)\}_{n=1}^N$, a solution of the household's decision problem, a location decision rule $\eta\left(n|s\right)$ and a probability measure of households over individual states μ such that: (1) The solution of the household's decision problem takes neighborhood characteristics $\{(Y_n, R_n, P_n)\}_{n=1}^N$ as given. (2) The location decision rule $\eta\left(n|s\right)$ is consistent with the solution of the household's decision problem. (3) The neighborhood characteristics are consistent with decision-implied neighborhood characteristics so that $Y_n = \widehat{Y}_n$ and $R_n = \widehat{R}_n$ for $n = 1, 2, 3, ..., N$. (4) Housing markets clear so that $L_n(P_n) = \widehat{D}_n$ for $n = 1, 2, 3, ..., N$. (5) The probability measure μ does not change over time so that $\mu' = \int_{[0,\bar{h}]\times Z} P((h, r, z), (\mathcal{A}, r, z'))d\mu$.

3 Illustrating the Mechanism

This section provides a graphical description of the mechanism producing the racial inequality trap. The panels in Figure 2 display the laws of motion for individual human

[15] A more precise definition of the transition function is provided in Appendix A5.

Figure 2: Human Capital Decision Rules (selected values of z).



The plotted laws of motion correspond to the actual solution of each of the three versions of the model. The functional forms, parameter values and solution algorithm are discussed in Section 4.1.2. The units in both axes are thousands of dollars per year.

capital that hold in numerical approximations to stationary equilibria of three versions of the model: One Neighborhood, No Racial Preferences and Full Model. The horizontal axis in each panel measures the market value of the parent's human capital, wh, and the vertical axis measures the child's future human capital, wh', expressed in thousands of dollars per year. In what follows, all lifetime money ammounts will be expressed in per-year terms. The curves depict how h' is determined by the household's characteristics and decisions (i.e., $h' = F(z, hl(s,n), Y_n)$ with n given by the location decision rule). Dotted black curves correspond to black households and gray curves correspond to white households. For each race, each curve corresponds to a value of innate ability, z. Curves are only plotted for 3 selected shock values (z_5, z_7 and z_9) out of the 10 values used in the numerical approximation.

The steady states corresponding to panels (b) and (c) feature $N = 2$ and sorting by earnings, so that one neighborhood is more affluent and has higher house prices than the other. In this case, location decisions for each (z, r) combination have a single threshold in the human capital dimension. Households with h above the threshold locate in the most affluent neighborhood and those with h below the threshold locate in the least affluent. The upward discontinuous jumps in the curves of panels (b) and (c) occur at these threshold values: To the left of the jump, the household locates in the least affluent neighborhood and to the right in the most affluent.

Additionally, the steady state corresponding to panel (c) features racial segregation: The least affluent neighborhood is predominantly black and the most affluent is predominantly white. In such context, racial preferences imply that every black household is more attracted to the least affluent neighborhood and less attracted to the most affluent neighborhood than an economically identical white household. For this reason, decision rules in panel (c) are asymmetric in that they display different human capital thresholds for each race. Specifically, for a given learning ability level, the white thresholds are lower than the black thresholds. This racial asymmetry generates intervals of parental human capital h where, for a given learning ability z, human capital h' is higher for white children. For example, consider a household with the highest ability level and parental human capital $wh = \$150,000$. If the household is black, the child's future human capital is dictated by the highest dotted black curve in panel (c), which gives a wh' value below $\$200,000$. If the household is white, the child's future human capital is given by the highest gray curve, which gives an wh' value above $\$250,000$. This asymmetry perpetuates black/white inequality.

4 Quantitative Relevance of the Model

This section argues the model is relevant for interpreting U.S. black/white earnings inequality. It is organized into three parts: calibration, empirical assessment and relating with external estimates.

4.1 Calibration

To keep the model computationally manageable the number of neighborhoods is $N = 2$. The next section thus finds an empirical counterpart to those two neighborhoods.

4.1.1 A Two-Neighborhood Representation of the U.S.

The vector of three characteristics $m_j = (\log Y_j, R_j, \log P_j)$ is measured for each residential location j in the dataset, where Y_j denotes average household earnings, R_j is the fraction of residents who are black and P_j is the price of a unit of housing services.[16] For each year, the locations in the dataset are split into two groups, denoted cluster C_1 and C_2, by applying the K-means clustering algorithm.[17] The algorithm chooses a partition $\{C_1, C_2\}$ of the set of locations $\{1, 2, 3, ..., J\}$ to solve

$$\min_{C_1,C_2} \sum_{n=1}^{2} \sum_{j \in C_n} \omega_j \left(m_j - \bar{m}(C_n)\right) \widehat{\Omega}^{-1} \left(m_j - \bar{m}(C_n)\right),$$

where $\bar{m}(C_n)$ denotes a vector with the average of m_j across the locations classified as members of cluster C_n, $\widehat{\Omega}$ is a diagonal weighting matrix containing the sample-wide variances of each of the components of vector m_j and scalar ω_j is a weighting variable proportional to location j's population size. This objective function leads to minimization of the variation of location characteristics *within* each cluster and maximization of the variation of location characteristics *between* clusters.

The two-neighborhood representation consists then of two representative reighborhoods (RNs). RN 1 is defined as the aggregate of locations in cluster C_1 and RN 2 is defined as the aggregate of locations in C_2.

The Census tract is the empirical definition of residential location employed.[18] Tract-level data are from the Neighborhood Change Database (NCDB) by GeoLytics Inc. The NCDB is a panel containing tract-level aggregates of demographic, income and housing information from the 1970, 1980, 1990, and 2000 decennial Censuses. The sample includes 17,082 tracts from 30 metropolitan statistical areas (MSAs). Included MSAs contain large populations (at least 1 million) and a substantial black population (at least 10 percent of the MSA's population is black). Further, only tracts for which black and non-hispanic white persons comprise more than 50 percent of the population. The results for year 2000 are robust to several modifications to variable definitions, sample selection and choice of weighting matrix (see Badel, 2014, pp. 167).[19]

Table 1 presents the characteristics of RNs in the year 2000. The table clearly summarizes the sorting by race and income observed in U.S. cities. RN 1, which contains 31 percent of the total population, is 61.9 percent black, while RN 2 is only 6.5 percent

[16] Average earnings Y_j are measured as average household earnings. Racial configuration R_j is measured as the number of black households divided the number of black households plus the number of non-Hispanic white households. The price of housing services P_j is measured as a constant-quality gross-of-tax unit price index derived from self-reported house prices. See Appendix A1 for further details.

[17] This algorithm is a basic tool from the pattern recognition literature. See Gordon (1999) for a standard reference.

[18] Census tracts are small geographical subdivisions of the U.S. designed by the Census Bureau and ideally contain $4,000$ persons. Their design aims at generating areas with homogeneous populations in demographic and economic terms, while their land area varies with population density.

[19] Also, see Appendix A1 for further details.

Table 1: Characteristics of Representative Neighborhoods in year 2000*

Location	*Demographics*		*Annual Hhold. Income ($)*		*Annual Hhold. Earnings ($)*	*House Prices ($)*
	%Black	% of Pop.	Black	White		
RN 1	61.9	31	40,400	47,000	42,000	131,800
RN 2	6.5	69	58,000	77,900	71,900	192,000
Combined	23.6	100	43,700	73,100	62,600	173,400
Ratio RN 1:RN 2			0.70	0.60	0.58	0.69

*Household earnings are not available by race in the NCDB. Average earnings and the price of housing services include "other race" households. All other figures exclude "other race" households. Earnings, income and housing prices are measured controlling for MSA fixed effects. The price of housing services is measured controlling for several measures of quantity and quality of housing and the distribution of commuting time to work. See Appendix A1 for further details.

black. Average earnings in RN 1 are 0.58 of those in RN 2 and the relative price of housing services in RN 1 with respect to RN 2 is 0.69.

The two-neighborhood representation in Table 1 accounts for 0.44, 0.62 and 0.23 percent of the sample variances of $\log Y_j$, R_j, and $\log P_j$, respectively, across the $17,082$ Census tracts in the sample in year 2000. These high R-squared values have two implications. First, a two-neighborhood representation provides an adequate balance between simplicity and accuracy. Second, a model matching Table 1 goes a long way in capturing the distribution of earnings, race and house prices across Census tracts.

Although the sample doesn't contain every MSA in the nation, the sample-wide black/white ratio of average household earnings is 0.60, which lines up well with the 0.60 ratio obtained from the national microdata sample used in Figure 1 for year 2000.

Table 1 displays qualitative properties highlighted in several existing two-neighborhood models and could be used to ask quantitative questions within them. For example, the fact that both prices and earnings are higher in RN 2 is consistent with the sorting equilibrium in Fernandez and Rogerson (1998), while the fact that average income is higher in RN 2 among both black and white households is consistent with the intraracially stratified equilibria analyzed in Sethi and Somanathan (2004). Table 1 can also pin down the extent of segregation when it is exogenous. Lundbergh and Startz (1998) and Bowles, Loury and Sethi (2008) show that the extent of segregation is crucial for the dynamic path of the economy.

Table 2 compares the characteristics of RNs across years. Over the sample period, the cross-neighborhood ratios of population, earnings and prices did not vary dramatically

Table 2: Characteristics of Representative Neighborhoods (all years)

Statistic	1970	1980	1990	2000
Fraction white in 1	0.43	0.3	0.32	0.38
Fraction white in 2	0.97	0.96	0.94	0.94
Fraction of population in RN 1	0.2	0.22	0.23	0.31
Avg. hhold. earnings ratio RN 1:RN 2	0.66	0.66	0.61	0.58
Housing price ratio RN 1:RN 2	0.75	0.64	0.66	0.69
Number of MSAs	30	30	30	30
Number of tracts	12,994	16,340	17,370	17,082

and neither did the racial configurations.[20] This suggests that the RN construction is consistent with the steady-state view adopted in the definition of equilibrium in Section 2. Figure 3 displays the geographical location of tracts in each cluster for Chicago and Detroit in 1970, 1980, 1990 and 2000.[21] Tracts from a cluster tend to be contiguous with each other, forming large parcels within each MSA, and this spatial configuration of the MSAs does not change much over time, except for an expansion of the area covered by each cluster.

To connect model and data, each Census tract is viewed as a separate space for social interactions and a separate housing market represented by either RN 1 or RN 2, and the characteristics of each of these RNs are matched by those of a neighborhood of the model economy.[22] In the next section functional forms for preferences, technology and shocks are specified; 4 parameters are set at values from external sources; and the remaining 13 parameters are set by matching 13 cross-sectional targets with corresponding model generated statistics.

4.1.2 Setting Functional Forms and Parameter Values

Table 3 summarizes the functional forms used. Production of human capital follows a standard CES. Parameter $\chi < 1$ imposes decreasing returns to scale; parameter γ controls the elasticity of substitution between effective units of parental time, hl and neighborhood average earnings, Y_n; and parameter A controls total factor productivity.

The innate ability process is modeled using the discrete state approximation to a

[20] Cutler, Glaeser, and Vigdor (1999) document a fall in racial segregation after 1970. They also show that the fall was much less pronounced in large cities. The evidence in this paper complements their view by showing that racial segregation, earnings ratios and house price ratios as measured by RNs remained nearly constant in large cities with a high fraction of black households.

[21] Maps of other MSA have similar properties and are available from the author. See Appendix A1 for a list of MSA included in the sample.

[22] An alternative and valid view would be that each tract is part of a larger parcel, with housing markets and social interactions defined at a larger geographical scale and segmented only across parcels. Under this alternative, one views each parcel as represented by a model's neighborhood.

Figure 3: Geographical Properties of Representative Neighborhoods for Chicago and Detroit (1970-2000)

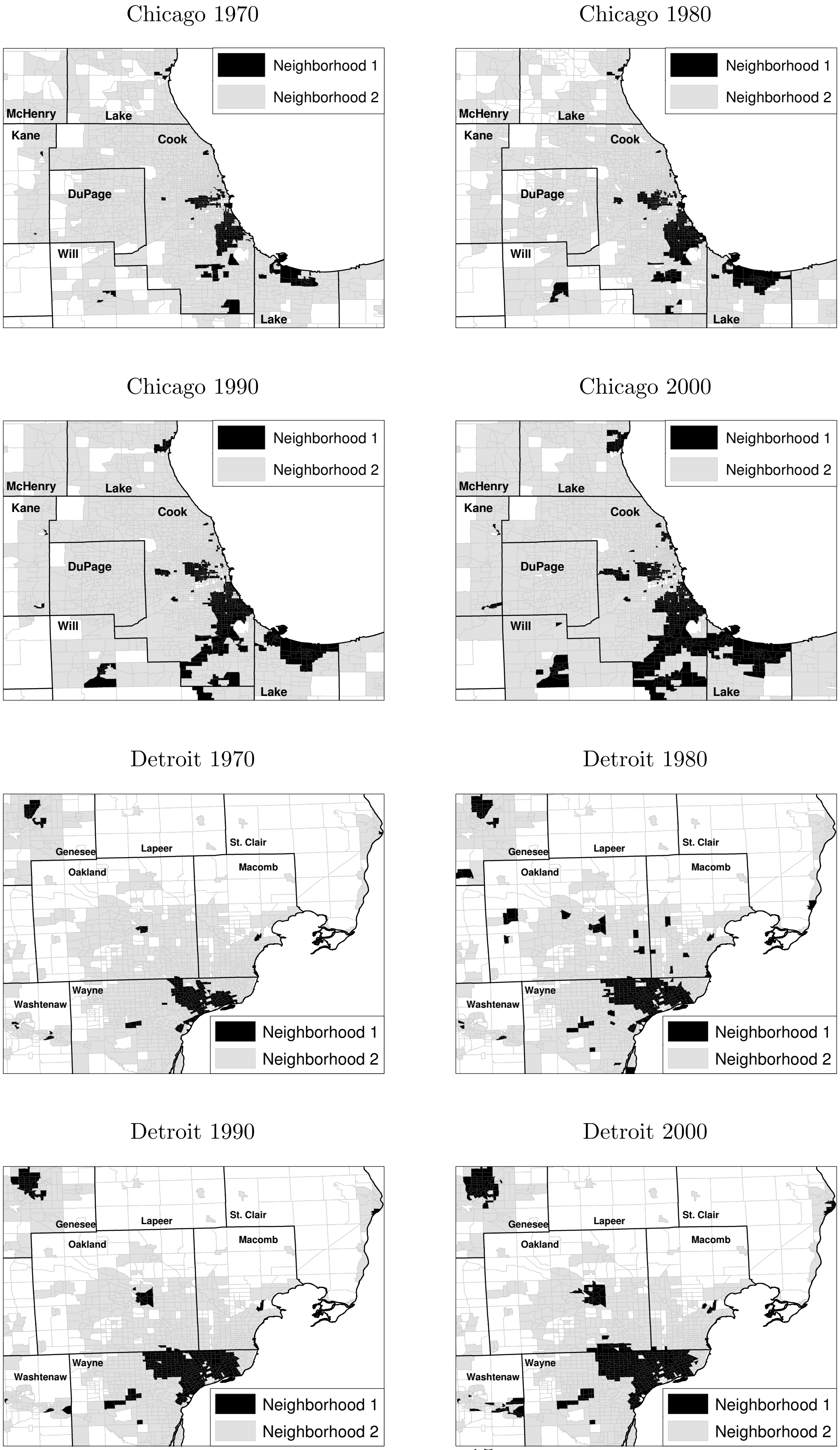


Table 3: Functional Forms

Human capital production function	$F(z, hl, Y_n) = e^z A[\lambda(hl)^\gamma + (1-\lambda)Y_n^\gamma]^{\frac{\chi}{\gamma}}$
Innate ability process	$\pi(z'\|z) =$Rouwenhorst$(p, q, \epsilon)_{10\times 10}$
Utility function	$u\left(c, g, R_n(r)\right) = \frac{1}{1-\sigma}\left\{\left[c^\alpha g^{1-\alpha} v(\phi(R_n, r))\right]^{1-\sigma} - 1\right\}$
Racial component	$v(\phi(R_n), r) = 1 - \kappa\left(\phi(R_n, r) - \phi^*\right)^2$
Supply of housing	$L_n(P_n) = L_n^0 P_n^\zeta$

continuous AR(1) process provided by Rouwenhorst (1986). Innate ability z takes 10 possible values located on a uniform grid centered at zero, with increments given by parameter ϵ. Transition probabilities across these values are governed by parameters p and q. Parameter p controls the persistence of high states and q controls the persistence of low states. The autocorrelation of the process is $p + q - 1$. Details on the construction of the transition matrix and a formula for the unconditional variance of this process can be found in Kopecky and Suen (2009).

The utility function assigns a share $1-\alpha$ of total period expenditures to housing.[23] The intertemporal elasticity of substitution and relative risk aversion are constant and controlled by parameter σ. The racial component of utility imposes a loss that increases quadratically as the racial configuration of the neighborhood deviates from the "ideal" racial configuration. The ideal racial configuration is given by parameter ϕ^*, the magnitude of the loss is controlled by parameter κ and the racial preference component $v(.)$ is measured in expenditure-equivalent units.[24]

Some parameter values are directly imposed: The population is set to be comprised of a fraction $\chi_B = 0.236$ of black households, which is the fraction in the sample used to construct Table 1. The fraction of current expenditures devoted to housing is set to $(1-\alpha) = 0.24$ following Davis and Ortalo-Magne (2011). The price elasticity of housing service supply in each neighborhood is set to $\zeta = 0.7$, similar to Fernandez and Rogerson

[23] Davis and Ortalo-Magne (2011) provide empirical evidence of a fixed share of housing in consumption expenditures. This evidence, as well as computational convenience, motivate the use of a Cobb Douglas specification to model the intra-temporal demand of g and c.

[24] This follows because the racial component multiplies the expression $c^\alpha g^{1-\alpha}$ which, at the optimum, is directly proportional to total period expenditures.

(1998).[25] the price of housing in Neighborhood 1 is normalized to $P_1 = 1$.[26]

The remaining 13 parameters are set by minimizing the squared percentage difference between 13 target facts and corresponding statistics calculated from the model. A parallel quasi-global numerical minimization algorithm similar to that described by Guvenen (2011) is used to search in the 13-dimensional space of parameter vectors.

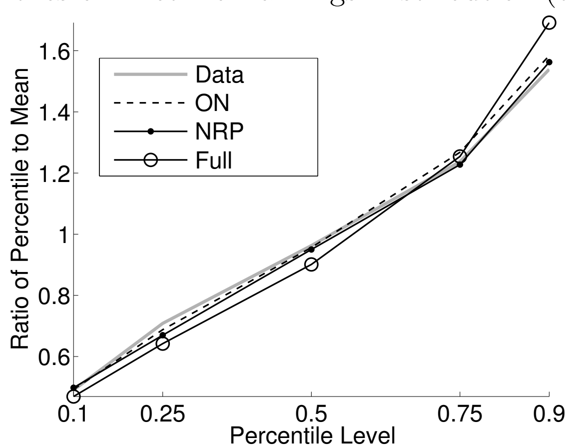
Three versions of the model are parameterized. These versions highlight the role of local externalities and racial preferences in producing the target facts. Model fit is presented in Table 4 for 8 of the 13 target facts. Fit for the remaining 5 targets is displayed in Figure 4. The One-Neighborhood (ON) version of the model is now parameterized.

Table 4: Model Fit (target facts 1-8)

Target	$E[y]$	$var[\log y]$	$E[whl]/E[y]$	P_1/P_2	Y_1	Y_2	R_1	R_2
Data	62,600	0.211	0.242	0.69	42,000	71,900	0.619	0.065
ON model	62,634	0.207	0.243	-	62,634	-	0.236	-
NRP model	62,066	0.212	0.232	0.69	42,688	71,512	0.236	0.236
Full model	62,593	0.240	0.262	0.69	41,947	71,824	0.618	0.065

The equilibrium racial configuration in the ON and NRP models is displayed for illustration purposes but not targeted. The values of empirical targets $E[y]$ and $var[log(y)]$ are from Table 1 and Appendix A3; the ratio of the average value of parental investments in children to average earnings, $E[whl]/E[y]$, is from ATUS data and calculations described in Appendix A4; and the values of Y_1, Y_2, R_1, R_2 and P_1/P_2 are from Table 1.

Figure 4: Percentiles of Lifetime Earnings Distribution (target facts 9-13)



This version consists of setting $N = 1$ and setting parameters $\lambda = 1$ and $\gamma = 1$ so that all households live in a single neighborhood and the production function of human capital

[25]Recent empirical estimates of the elasticity of the housing stock to housing prices range from 0.08 to 29.9, see Mayer and Somerville (2000) and Malpezzi et al. (2005), respectively.

[26]The housing price normalization is not imposed in computing counterfactual equilibrium.

does not depend on neighborhood average earnings. The ON version is calibrated by choosing the 8 nonzero parameters from A through L_1^0 (from left to right in Table 5) to match the ratio of average parental investment to average earnings, $E[whl]/E[y]$, plus the 7 targets describing the cross-sectional lifetime earnings distribution (i.e., $E[y]$, $var[\log(y)]$ and the 5 percentiles of lifetime earnings in Figure 4). This calibration strategy used for all models leaves the intergenerational correlation of earnings out of the vector of moments and uses it for the empirical assessment in the next section. In previous work, different values of this correlation have been targeted without dramatically altering the results (see Badel, 2009, pp. 87). Here the persistence parameters of the shock distribution are partly by the shape of the stationary earnings distribution together with all other targets.

Table 4 and Figure 4 show that the ON model can reproduce the overall distribution of lifetime earnings and the magnitude of parental investments in the data but, by construction, is incapable of reproducing the neighborhood characteristics P_1/P_2 to R_2 (from left to right in Table 4).

Compared with the ON model, the NRP model contains three additional parameters (λ, γ, L_2^0) and is parameterized using three additional moments: $P_1/P_2, Y_1$ and Y_2. In this version, differences in house prices across neighborhoods can be sustained in equilibrium only if the earnings externalities differ across neighborhoods. Therefore, given the relative house price ratio P_1/P_2, the equilibrium pattern of segregation by earnings, which is captured by Y_1 and Y_2, is determined by the parameters governing the externality.

The third parameterization corresponds to the full model. Compared to the NRP model, the full model includes two additional parameters controlling racial preferences (κ and ϕ^*) and is estimated using two additional moments corresponding to the fraction black in each neighborhood (R_1 and R_2). Parameter values vary appreciably across the three versions of the model, suggesting that flexibility in every parameter is required in order to match all facts closely.

The parameter search procedure did not produce evidence of identification issues. First, a quasi-global search was performed over the parameter space and it was not the case that several parameter vectors were able to deliver a reasonable fit to the target facts.[27] Second, since the equilibrium variables are part of the vector of targets, the search procedure effectively explores all possible steady states of the model, bypassing

[27] The search was performed by first evaluating the objective of the calibration at 10,000 randomly selected values of the parameter vector. Then, the K-means clustering algorithm was used to classify the group of 1,000 vectors achieving the best fit to form 9 promising regions of the parameter space. Finally, a local search within each of the 9 regions using the Nelder-Mead simplex algorithm. For each of the 3 model versions, the 9 searches yielded only 1 vector of parameter values producing a reasonable fit to every target. The reported model outcomes are obtained by fixing the parameter values at those providing the best fitting vectors and computing a steady state equilibrium according to the algorithm in Appendix A6.

Table 5: Parameter Values

Model	Production Parameters				Preference Parameters				Shock Parameters			Supply of Housing Par.	
	λ	γ	A	χ	κ	ϕ^*	σ	β	p	q	ε	L_1^0	L_2^0
ON	**1**	**1**	7.953	0.232	**0**	**0**	3.232	0.579	0.307	0.888	0.501	15,659	**0**
NRP	8.52×10^{-4}	-4.613	6.118	0.507	**0**	**0**	3.037	0.876	0.504	0.737	0.323	3,497	7,624
Full	0.00834	-3.757	4.143	0.746	0.142	0.877	1.942	0.529	0.692	0.681	0.279	3,240	6,546

Note: Parameter values in boldface are imposed outside the estimation procedure.

identification issues related to multiple equilibria.[28] The value of σ lies within the standard range of values employed in the macro literature and, assuming a 25-year period length, the annualized value of the discount factor takes the value $\beta^{\frac{1}{25}} = 0.529^{\frac{1}{25}} = 0.98$, which is also within the standard range of values employed in the literature. The autocorrelation of the z shocks is $p + q - 1 = 0.69 + 0.68 - 1 = 0.37$ and their unconditional variance is 0.18. Both the autocorrelation (0.74) and unconditional variance (0.24) of log earnings produced by the model are substantially above those of the shocks, highlighting the role of the incompleteness of intergenerational financial markets in amplifying and transmitting innate ability shocks. The plausibility of the parameters controlling externalities and racial preferences is addressed in Sections 4.3 and 4.4, respectively.

4.2 Empirical Assessment

This subsection asks whether the calibrated equilibrium of the full model is consistent with non-targeted facts. The first column of Table 6 presents a key result of the paper: The full model produces a black/white ratio of average household earnings, $E[y|B]/E[y|W]$, of 0.79. This ratio implies a 21 percent black/white earnings gap, which equals 52 percent of the 40 percent gap in Figure 1.

Some readers may suspect that targeting each neighborhood's black population shares (R_1, R_2) and average earnings (Y_1, Y_2) arithmetically imposes some degree of black/white inequality. However, it is easily shown that for a given vector (R_1, R_2, Y_1, Y_2), the black/white average earnings ratio $(E[y|B]/E[y|W])$ can take any value between zero

[28] For example, for the full model version, every evaluation of the objective function of the calibration, the values of the equilibrium variables (Y_n, R_n) perceived by households are set to their empirical target values. Also, $P_1 = 1$ and P_2 is set so as to directly match the target price ratio P_1/P_2. Then steps 1-2 of the algorithm for computing stationary equilibria in Appendix A6 are followed to obtain implied model statistics including $(\widehat{Y}_n, \widehat{R}_n)$ to compute the objective function of the calibration. Note that the model is not necessarily in equilibrium at every evaluation. However, a parameter vector providing a good fit to the targets causes "decision implied" values $(\widehat{Y}_n, \widehat{R}_n)$ to be near their "perceived" values (Y_n, R_n), which have been fixed at the values from data, so equilibrium conditions involving these variables are nearly satisfied. The quasi-global search thus effectively allows for any of steady state of the model so long as it nearly matches the data under one of the parameter vectors considered.

Table 6: Additional Facts

Model	$E[y\|B]/E[y\|W]$	$E[whl\|B]$	$E[whl\|W]$	$corr(\log y', \log y)$
Data	0.6	7,970	17,230	$[0.23, 0.85]$
ON model	1.00	15,243	15,243	0.72
NRP model	1.00	14,440	14,440	0.63
Full model	0.794	12,946	15,829	0.742

The empirical value of $E[y|B]/E[y|W]$ is from Table 1; the values of $E[whl|B]$ and $E[whl|W]$ are from ATUS data and calculations described in Appendix A4; and the interval for point estimates of $corr(y', y)$ is from Mazumder (2005), Table 4.

and infinity consistently with two-neighborhood two-race arithmetic identities.[29]

As mentioned in the introduction, I interpret the unexplained component of the earnings gap as reflecting that the model abstracts from factors amplifying early human capital differences and from direct forces affecting earnings and parental investments.

The second and third columns of Table 6 show that the pattern of parental investments produced by the model is qualitatively consistent with the data: For the full model, the average value of investments in children of black households, $E[whl|B]$, is substantially lower than that of white households, $E[whl|W]$.

The last column of Table 6 measures the intergenerational persistence of earnings $corr(\log y', \log y)$. The model's intergenerational persistence of earnings is well within the range of estimates reported by Mazumder (2005). This result suggests the intergenerational transmission channels featured in the model are not exaggerated.

The mobility of dynasties across neighborhood types is a crucial source of information for theories of endogenous sorting and earnings distributions. In some models such as those in Durlauf (1996) and Benabou (1993) dynasties can remain forever in the same neighborhood while other models such as that in Fernandez and Rogerson (1998), dynasties eventually circulate across all neighborhoods.

[29] Notice that the black white earnings ratio can be written in terms of (1) calibration targets and (2) black average earnings by neighborhood and neighborhood population:

$$\frac{E[y|B]}{E[y|W]} = \frac{S_1 R_1 y_1^B + (1-S_1) R_2 y_2^B}{S_1(1-R_1)y_1^W + (1-S_1)(1-R_2)y_2^W}$$

$$\frac{E[y|B]}{E[y|W]} = \frac{S_1 R_1 y_1^B + (1-S_1) R_2 y_2^B}{S_1(Y_1 - R_1 y_1^B) + (1-S_1)(Y_2 - (1-R_1)y_2^B)}$$

Where variable y_n^r denotes average earnings for agents with race r in neighborhood n and S_1 is the share of total population located in neighborhood $n = 1$. The second line follows from substituting expressions for white earnings from the definition of neighborhood averge earnings,

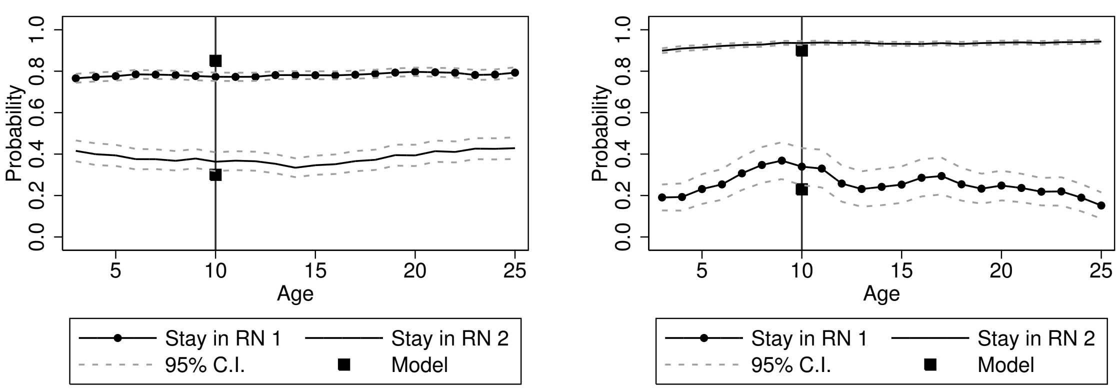
$$Y_n = R_n E[y|n, B] + (1-R_n) E[y|n, W] \; n = 1, 2.$$

The result follows from fixing (R_1, R_2, Y_1, Y_2), and varying $S_1 \in (0, 1)$, $y_1^B \in [0, Y_1/R_1]$ and $y_2^B \in [0, Y_2/R_2]$. The latter three variables are not directly determined by the calibration.

I employ geocoded PSID restricted-access data in order to track households across census tracts and determine whether their tract of residence was part of RN 1 or RN 2. The histories of neighborhood type are used to measure the probability that a household of age a and race $r = \{B, W\}$ moves from a neighborhood type n_a to a neighborhood type n_{a+25} in 25 years.[30] Figure 5 shows significant flows of black and white households

Figure 5: Probability of Living in a Same-type Neighborhood in 25 Years (by Age and Race)

(a) Black Households (b) White Households



At the vertical line, the probabilities that a black household lives in RN 1 at age 35 conditional on living in RN 1 at age 10 is $Pr_B(n' = 1|n = 1) = 0.77$, while the probability of living in RN 2 at age 35 conditional on living in RN 2 at age 10 is $Pr_B(n' = 2|n = 2) = 0.36$. For white households the probabilities are $Pr_B(n' = 1|n = 1) = 0.34$ and $Pr_B(n' = 2|n = 2) = 0.94$.

across neighborhood types as all probabilites of staying in a particular neighborhood type are substantially lower than 1. The probability of staying in RN 1 is higher for black households while the probability of staying in RN 2 is higher for white households. This pattern is consistent with the substantial racial gap in upward mobility across quartiles of neighborhood income found by Sharkey (2008) but the mobility measure used here has the advantage of considering several characteristics of neighborhoods (instead of only income) and providing a geographic point of reference (see Figure 3). The square markers laid over the vertical lines in Figure 5 depict the intergenerational transition probabilities produced by the model, showing they are close to the empirical probabilities.

Finally, the two crucial forces in the model are neighborhood human capital externalities and racial preferences. Are the magnitudes of these forces in the calibration inconsistent with external estimates?

[30] A household is defined to be any PSID individual who was ever a "head of household" or a "wife." In the PSID, households come from two samples. The core sample was designed to be nationally representative in 1968, while the Survey of Economic Opportunity oversamples the poor. Both samples are used here to obtain a reasonable sample size. Since the statistics reported condition on race and neighborhood, the distortion from this source is expected to be small. Appendix A2 further describes data and methodology.

4.3 Relating to External Estimates: Earnings Externalities

Neighborhood externalities are hard to pin down using reduced-form methods. The main difficulty is the endogeneity of location choices, which scrambles the impact of neighborhood characteristics with the impact of an individual's characteristics on the individual's outcome. I now examine recent research addressing this issue in three ways.

First, Cutler and Glaeser (1997), Bayer, Fang and McMillan (2011) and Card and Rothstein (2007) focus on city-wide averages. They estimate that, for young people, a city's full racial earnings gap, and one fourth of the racial SAT score gap are explained by city-level measures of racial segregation. The model is consistent with these results in two ways. First, without segregation there is no racial inequality in this model.[31] Second, if variation in equilibrium segregation is generated by varying either the racial preference parameter κ or the fraction of each race in the overall population, χ_B, and computing steady states at different values of these variables, the elasticity of steady state racial inequality to racial segregation is approximately 1.[32]

Second, Katz, Kling and Liebemann (2007) examine data from the Moving to Opportunity (MTO) program in which low-income households were randomly selected to receive housing vouchers. They find no evidence of strong treatment effects and interpret this finding as evidence against the importance of neighborhood externalities. Table 7

Table 7: Comparing Treatments: MTO versus Representative Neighborhoods

	Representative Neighborhoods		MTO Neighborhoods	
	RN 1	RN 2	Control	Treatment
Percentile of poverty rate	85.61	46.53	98.64	95.05
Percentile of employment rate	13.06	56.49	1.60	4.14

Source: Katz, Kling and Liebemann (2007), Table 1 and author's calculations.

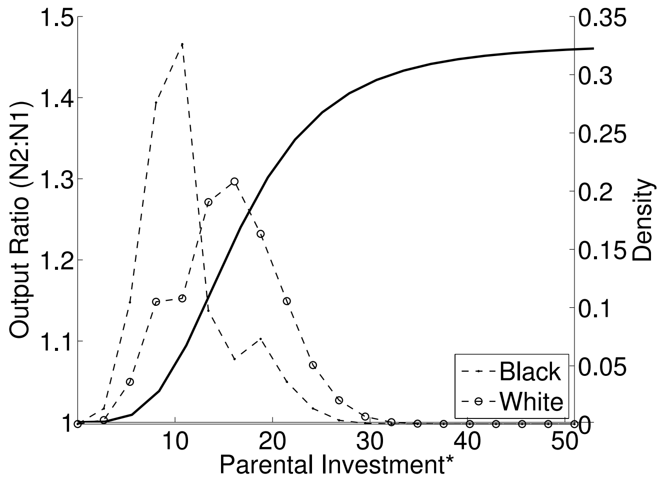
puts the MTO evidence into the perspective of this paper by establishing the position of the model's neighborhoods and the position of the MTO neighborhoods in the distribution of neighborhood characteristics for the year 2000 from the sample described in Appendix A1. Table 7 shows that a household moving from Neighborhood $n = 1$ to Neighborhood $n = 2$ in the model (hereafter N1 and N2) effectively moves from the 86th to the 47th percentile of the neighborhood poverty distribution and from the 13th to the

[31]Both the racially integrated steady state (to be discussed in the following section) and the steady state of the model without racial preferences described in Table 4 feature no racial segregation and no racial inequality.

[32]For calculating this elasticity, racial segregation is measured by the index of dissimilarity. The result holds at all levels of racial segregation except very close to full segregation, where racial inequality is actually decreasing in racial segregation. A detailed description of these results is available from the author upon request.

56th percentile of the neighborhood employment distribution, while a household moving from the average control to the average treatment neighborhood of the MTO experiment only moves from the 99th to the 95th percentile of poverty and from the 1st to the 4th percentile of the employment distribution. These differences in the treatment can thus be viewed as large enough to reconcile the importance of local externalities in the model with the lack of treatement effects found for the MTO.

Figure 6: Model Magnitude of Neighborhood Earnings Externalities



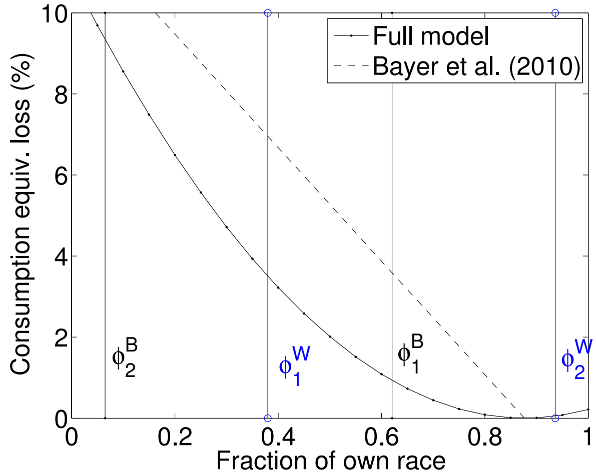
*The horizontal axis is measured in thousands of dollars per year.

Third, Altonji and Mansfield (2011) address the endogeneity issue by providing bounds instead of point estimates for the neighborhood effects.[33] Their work is the most informative for this section's purpose because they also focus on the combined strength of school quality and neighborhood characteristics without aiming to disentangle these two forces, and because they also focus on lifetime measures of earnings. They find that, everything else constant, moving from the 10th to the 90th decile of the neighborhood quality distribution increases a child's permanent earnings by between 17 and 26 percent.[34] Figure 6 plots the ratio of future human capital obtained in N2 versus that obtained in N1. The horizontal axis measures parental investment in units of effective labor. The ratio is increasing in investment reflecting the assumption of increasing differences that produces sorting by human capital. The steady-state probability density of parental investments in the inequality trap is shown in the background for each race. In the interval where

[33]The bounds depend on whether the unexplained part of school-level variation in permanent earnings is attributed to neighborhood effects or to self-selection.

[34]Their measure of neighborhood quality contains 12 variables describing the school such as student-teacher ratio and school enrollment and 6 variables describing the neighborhood characteristics such as whether the school is in an urban or suburban area.

Figure 7: Magnitude of Racial Preferences



density is positive, the output ratio ranges roughly between 1 and 1.4, suggesting a maximum output increase of 40 percent. Integrating the output ratio against the investment densities gives a weighted average increase in output of 11.4 percent for black households and 21.4 percent for white households. These numbers provide a rough comparison of externalities in the model and those estimated in Altonji and Mansfield (2011) suggesting that earnings externalities are not overstated in the calibration. The comparison is rough, however, mainly because moving from N1 to N2 may not be exactly equivalent to moving from the 10th to the 90th percentile of Altonji and Mansfield's neighborhood quality distribution. However, distortions from this source do not seem likely to affect the interpretation given to the comparison because Table 7 shows that N1 and N2 are indeed quite far apart in some dimensions along the distribution of neighborhood quality.

4.4 Relating to External Estimates: Racial Preferences

The estimates of racial preferences are now considered. The solid line in Figure 7 plots the racial preference term of period utility in the model. The horizontal axis measures the fraction of own race in the neighborhood and the vertical axis measures the associated consumption-equivalent loss. The minimum of the solid curve corresponds to the loss at a neighborhood with the ideal racial configuration, ϕ^*. The vertical lines in the figure represent the racial configuration faced by households of each race in each neighborhood of the full model. The intersections of solid curve and vertical lines represent the losses for these households. The dotted line represents the marginal preference for own race estimated by the most closely related empirical study: Bayer et al. (2010). They use detailed information of white buyers and sellers from every housing transaction in the

San Francisco MSA between 1994 and 2003 to estimate a model in which forward-looking households subject to exogenous earnings make savings and residential location choices. Their households have preferences over a large vector of house and neighborhood characteristics including the fraction of the neighborhood's population that is white. Their main estimates of the racial preference indicate that the willingess to pay for an additional 10 percent of one's own race in the neighborhood is between 1.12 and 1.9 percent of household income. The slope of the dotted line in Figure 7 implies a 1.4 percent willingness to pay, close to the midpoint of their estimates. Visual comparison of the slopes of the racial preference specification in this paper and the empirical estimates suggests this paper is not assigning an unrealistically large role to this force.

5 The Inequality Trap View

I numerically establish that the asymmetry introduced by racial preferences can imply the existence of multiple steady-state equilibria. Several equilibria are obtained by varying the initial conditions provided to the computational algorithm.[35] The alternative equilibria simply permute the roles of each race and/or each neighborhood. For example, in some equilibria white households have lower human capital than black households and/or Neighborhood $n = 1$ (N1 hereafter) is more affluent than Neighborhood $n = 2$ (N2 hereafter). There are two exceptions: First, there is a fully racially segregated equilibrium where the two neighborhoods function as separate economies and there is virtually no racial inequality. Second, there is another steady state equilibrium with sorting by human capital, full racial integration and no racial inequality, which I will refer to as the "integrated" steady state. The existence of the integrated steady state warrants interpreting the racially unequal equilibrium highlighted in the calibration as a "trap".[36] Although "poverty trap" is more common terminology than "inequality trap", the latter seems more appropriate here. One reason is that the mechanism presented here does not rely on increasing returns to scale. Moreover, the focus here is on distribution and not on aggregate income, which, as shown by Table 8, does not vary much across the integrated and inequality trap steady states. Table 8 compares statistics of the integrated steady state and the inequality trap. In the table only the racial configurations and the black/white earnings ratio differ appreciably across steady states.

[35] The algorithm is described in Appendix A6 and detailed results are available from the author upon request.

[36] In the integrated steady state all neighborhoods have the same racial configuration so racial preferences are just a race-specific constant, inoccuous to location and investment decisions. This leads to symmetric decision rules and therefore to identical long run distributions of human capital across race.

Table 8: Characteristics of Selected Steady States

Steady State	$E[y]$	$var[\log y]$	$\frac{E[whl]}{E[y]}$	$\frac{P_1}{P_2}$	$\frac{Y_1}{Y_2}$	R_1	R_2	$\frac{E[y\|B]}{E[y\|W]}$	$corr(\log y', \log y)$
Inequality Trap	62.593	0.240	0.262	0.690	0.584	0.618	0.065	0.794	0.742
Integrated	62.788	0.243	0.264	0.639	0.527	0.236	0.236	1.00	0.772

6 Does Macro Context Matter?

A growing literature highlights the potential of human capital policy to improve lifetime earnings and other key outcomes at a low cost (see Carneiro and Heckman, 2003). This section asks whether the macroeconomic context matters for human capital policies aimed at reducing black/white inequality.

The answer provided by this model is that the success of human capital policies depends critically on their size. In particular, if the policy intervention is not extensive enough to affect the macroeconomic context, the location decisions of households will undo the equalizing effect of the policy over just a few generations.

This answer follows from considering the long-run effects of an ideal human capital intervention. Specifically, a randomly selected black household is magically endowed with the human capital stock of a randomly chosen white household. Then the treated household's dynasty is followed for several generations as it makes optimal location and investment decisions.

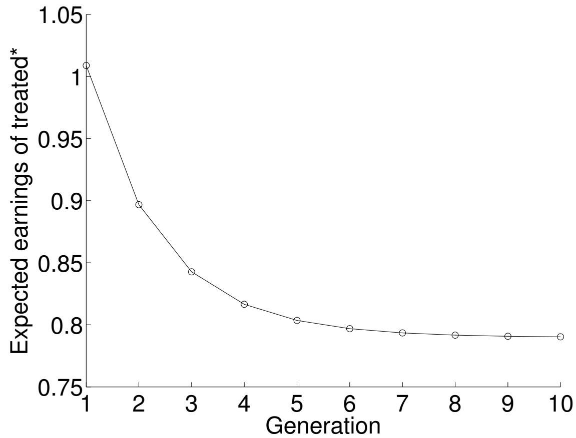
Figure 8 plots the expected earnings of the treated dynasty as a fraction of white average earnings.[37] Expected earnings start slightly above the white average, then drop rapidly and finally converge at 0.79 of white average earnings.

The key assumption of the experiment is that the intervention is small so the macro context faced by the treated dynasty is that of the inequality trap steady state.

As shown in Figure 2(c), such macro context leads black and white households to make asymmetric location decisions. Despite having the same expected human capital, the first generation of the treated dynasty locates in N1 with higher probability than a white household. This asymmetry affects human capital accumulation in two ways. First, it lowers the productivity of parental investments and, second, it leads households located in N1 to reduce the amount invested, compared with what they would invest if located in N2. These two effects lead to a reduction in the expected human capital of the second generation of the treated dynasty with respect to the average white household. This reduction in human capital increases the probability that the second generation locates

[37] The expectation is taken over (i) the stock of human capital assigned to the household and (ii) the dynasty's history of innate ability shocks.

Figure 8: A Small Human Capital Intervention Program



*Normalized dividing by the average earnings of white households.

in N1, leading to further human capital reductions for generation 3 and so on. The effects of the policy thus erode rapidly: 51.3 percent of the policy's effect has disappeared by the second generation and 88 percent has disappeared by the fourth generation. The process continues until the treated dynasty's expected location choice, expected human capital and expected earnings reach those of the average black household from the inequality trap.

Concluding Remarks

This paper endows the Loury-Becker-Tomes dynasties with race and with racial preferences like those in the Schelling model of racial residential segregation. The paper shows this coupling of staple models produces a rich model economy that can be applied to study black/white inequality - a critical feature of the U.S. economy.

A quantitative application of a simple rendition of this model employing only two neighborhoods produces one half of the black/white average earnings gap together with several other features of the data.

The calibrated model reveals the existence of additional steady states. In particular, there is a steady state where all neighborhoods are racially integrated and racial inequality is null. The existence of this alternative steady state suggests interpreting the U.S. earnings distribution as currently stuck in a racial inequality trap.

A somewhat surprising insight provided by the calibration is that even though racial preferences are the engine of this inequality trap, racial integration implies large welfare gains for black households and relatively small losses for white households. This is true even though racial preferences are assumed to remain fixed, and not diminish, in the face of racial integration.

Lastly, Martin Luther King Jr.'s dream of racial equality and integration has not yet been fulfilled. Under this paper's interpretation of the current situation, even ideal human capital policies are ineffective for that task if their scale is insufficient to alter the broad pattern of residential segregation observed in many U.S. cities.

References

1. Aiyagari, R., (1994) "Uninsured Idiosyncratic Risk and Aggregate Savings," *Quarterly Journal of Economics*, 109, 659−684.

2. Altonji, J., and R. Mansfield , "The Contribution of Family, School, and Community Characteristics to Inequality in Education and Labor Market Outcomes," in *Whither Opportunity? Rising Inequality and the Uncertain Life Chances of Low-Income Children*, edited by Greg Duncan and Richard Murnane (Russell Sage, 2011).

3. Arrow, K., "The Theory of Discrimination," in *Discrimination in Labor Markets*, (Princeton University Press, 1973, pp. 333).

4. Badel, A., "Permanent Racial Inequality", Georgetown University, doctoral dissertation, 2009.

5. Badel, A., (2014) "Representative Neighborhoods Of The United States", *Federal Reserve Bank of St. Louis Review* , Vol. 96, No. 2, pp. 147-172.

6. Bayer, P., H. Fang, and R. McMillan, "Separate When Equal? Racial Inequality and Residential Segregation," *NBER Working Paper* 11507, 2011.

7. 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.

8. Bayer, P., R. McMillan, A. Murphy, and C. Timmins, "A Dynamic Model of Demand for Houses and Neighborhoods," *NBER Working Paper* 17250, 2010.

9. Bayer, P., R. McMillan, and K. Reuben (2004), "What drives racial segregation? New evidence using Census microdata," *Journal of Urban Economics*, 56(3), 514-535.

10. Becker, G., *The Economics of Discrimination,*(Chicago, University of Chicago Press, 1957).

11. Becker, G., and N. Tomes (1986), "Human Capital and the Rise and Fall of Families," *Journal of Labor Economics*, 4(3), S1−S39.

12. Benabou, R. (1993), "Workings of a City," *Quarterly Journal of Economics*, 108, 619−652.

13. Bowles, S., G. Loury, and R. Sethi, "Group Inequality," *Mimeo*, Brown University, 2008.

14. Bowlus, A., and Z. Eckstein (2002), "Discrimination and Skill differences in an Equilibrium Search Model," *International Economic Review*, 43(4), 1309-1345.

15. Card, D., and J. Rothstein (2007), "Racial Segregation and the black/white Test Score Gap," *Journal of Public Economics*, Volume 91(11−12), 2158-2184, ISSN 0047-2727.

16. Carneiro, P., and J. Heckman,"Human Capital Policy," in *Inequality in America: What role for human capital policies?,* edited by Heckman, J. and A. Krueger (MIT Press, 2003).

17. Coate, S., and G. Loury (1993), "Will Affirmative Action Eliminate Negative Stereotypes?," American Economic Review, 83(5), 12201240.

18. Cutler, D., and E. Glaeser (1997), "Are Ghettos Good or Bad?," *The Quarterly Journal of Economics*, 112(3), 827−872.

19. Cutler, D., E. Glaeser, and J. Vigdor (1999), "The Rise and Fall of the American Ghetto", *Journal of Political Economy*, 107(3), 455-506.

20. Davis, M., and F. Ortalo-Magne (2011), "Household Expenditures, Wages, Rents," *Review of Economic Dynamics*, 2, 248−261. .

21. Durlauf, S. (1996), "A Theory of Persistent Income Inequality," *Journal of Economic Growth*, 1, 75-93.

22. Fang, H., and A. Moro, "Theories of Statistical Discrimination and Affirmative Action: A Survey," *Handbook of Social Economics*, Vol. 1A, (The Netherlands: North-Holland, 133-200, 2011).

23. Gordon, A., *Classification* (Chapman and Hall/CRC Monographs on Statistics and Applied Probability, 2nd Edition, 1999).

24. Guvenen, F. (2011), "Macroeconomics with heterogeneity: a practical guide," *Federal Reserve Bank of Richmond Economic Quarterly*, 97(3), 255-326.

25. Fernandez, R., and R. Rogerson (1998), "Public Education and Income Distribution: A Dynamic Quantitative Evaluation of Education-Finance Reform," *American Economic Review*, 88(4), pages 813-33, September.

26. Guryan J., E. Hurst, and M. Kearney (2008), "Parental Education and Parental Time with Children," *Journal of Economic Perspectives*, 22(3), 2346.

27. Green, Richard K., Stephen Malpezzi, and Stephen K. Mayo. (2005). "Metropolitan-Specific Estimates of the Price Elasticity of Supply of Housing, and Their Sources." American Economic Review, 95(2): 334-339.

28. Huggett, M. (1993), "The Risk Free Rate in Heterogeneous Agents Incomplete Insurance Economies," *Journal of Economic Dynamics and Control*, 17, 953−969.

29. — (1997), "The one-sector growth model with idiosyncratic shocks: steady states and Dynamics," *Journal of Monetary Economics*, 39, 385−403.

30. Kopecky, K., and R. Suen (2009), "Finite state Markov-chain approximations to highly persistent processes," *Review of Economic Dynamics*, 13, 701−714.

31. Katz, L., Kling, J. and J. Liebman (2007), "Experimental Analysis of Neighborhood Effects," *Econometrica*, 75(1), 83−119.

32. Loury, G., "A Dynamic Theory of Racial Income Differences," *Discussion Papers 225*, Center for Mathematical Studies in Economics and Management Science, Northwestern University, 1976.

33. — (1981) ,"Intergenerational Transfers and the Distribution of Earnings," *Econometrica*, 49(4), 843−867.

34. — (1998), "Discrimination in the Post-Civil Rights Era: Beyond Market Interactions," *Journal of Economic Perspectives*, 12(2), 117−126.

35. Lundberg, S., and R. Startz (1988), "On the Persistence of Racial Inequality," *Journal of Labor Economics*, 16(2), 292−323.

36. Mayer, C. and Somerville, T., "Residential Construction: Using the Urban Growth Model to Estimate Housing Supply." *Journal of Urban Economics*, Vol. 48, No. 1, pp. 85-109, July 2000.

37. Mazumder, B. (2005), "Fortunate Sons: New Estimates of Intergenerational Mobility in the U.S. Using Social Security Earnings Data," *Review of Economics and Statistics*, 87(2), 235-255.

38. Moro, A. (2003), "The effect of statistical discrimination on black-white wage inequality: estimating a model with multiple equilibria," *International Economic Review*, 44(2), 457−500.

39. — , "Basic Skills and the black/white Earnings Gap," in *The black/white Test Score Gap*, edited by C. Jencks and M. Phillips (Washington, DC: Brookings Institution, 480−497, 1998).

40. Rouwenhorst, G., "Asset pricing implications of equilibrium business cycle models," in *Frontiers of Business Cycle Research* , edited by T.F. Cooley and E.C. Prescott (Princeton University Press, 1995).

41. Schelling, T. (1971), "Dynamic Models of Segregation," *J. Math. Sociology*, 1, 143−186.

42. Sethi, R., and R. Somanathan (2004), "Inequality and Segregation," *Journal of Political Economy*, 112(6), 1296−1321.

43. Sharkey, P. (2008), "The Intergenerational Transmission of Context," *American Journal of Sociology*, 113(4), 931−69.

44. Todd, P., and K. Wolpin (2007), "The Production of Cognitive Achievement in Children: Home, School, and Racial Test Score Gaps," *Journal of Human Capital*, 1(1), 91−136.

A1 Representative Neighborhoods

Census tract level data are from the Neighborhood Change Database (NCDB) by GeoLytics Inc. NCDB is a panel of Census tracts containing tract-level aggregates of micro-level population and housing information from the 1970, 1980, 1990, and 2000 decennial Censuses. Data from all years are normalized to tract boundaries as defined in 2000. This is an advantage of the NCDB with respect to Census-provided data. Consistent tract boundaries allow me to match geocoded data from the PSID, where households' locations are expressed in year 2000 tract boundaries.[38]

A1.1 Tract Sample and Variables

Sample selection criteria seek to characterize the joint distribution of (Y, R, P) in large U.S. cities with a sizable black population. The operational counterpart of a city is the MSA. Tracts must satisfy the following conditions in at least one year to be included in the sample: contains at least 200 households; population density is above 200 persons per square kilometer; share of population living in group quarters is less than 25 percent; combined black and non-Hispanic white population shares are at least 50 percent; is located in an MSA with population over 1 million[39]; the tract is located in an MSA where 10 percent or more households are black. The NCDB contains geographical identifiers for 65,443 Census tracts. Table A1 displays the Census tracts excluded by each criterion in each year and the final sample size.

Average labor earnings in a tract (Y_j). Average household earnings are used to measure differences in earnings across neighborhoods. To control for differences across MSAs the following steps are taken: At each Census year, regress the log earnings against MSA dummies. Normalize the residuals from these regressions by adding the sample mean of log average household earnings in each year in the tract sample; exponentiate; the result is the measure of Y_j used.

Percentage of Population of black race in a tract (R_j). This variable is measured as the ratio of the black population to the sum of the black and the non-Hispanic white populations in a Census tract. For 1970 the non-Hispanic white share is unavailable. Therefore, it is imputed as a function of the white and Hispanic population shares.[40]

Price of housing services in a tract (P_j). This variable is derived from house values and characteristics reported by homeowners. In order to extract the price component (as opposed to the quantity component) of housing expenditures from house values the following steps are taken: At each Census year regress the log average tract-level house values against a set of housing and neighborhood characteristics.[41] Normalize the

[38]For year 2000 I complement the NCDB using some variables from the 2000 decennial Census that are not available in the NCDB. In particular, average household income by race variables are obtained from the Summary File 3 of the 2000 decennial Census. These variables are not available in the NCDB.

[39]MSA population is adjusted for population growth. Population in a given year is defined as the population the MSA would have in year 2000, assuming its population grows at the same rate as national population.

[40]Two steps are taken to perform the imputation: Regress the non-Hispanic white population share on the white share and the Hispanic share in year 2000. Using the coefficients from this regression and the observed white and Hispanic shares in 1970, predict the non-Hispanic white share in 1970.

[41]This set of housing characteristics contains the average number of rooms in tract units, the distri-

Table A1: Tract Sample Selection Criteria

	1970	1980	1990	2000
Tracts within MSA's	65,451	65,451	65,451	65,451
Deleted Observations:				
Tract is empty or missing variables	26,823	18,699	15,487	15,212
Less than 200 households in tract	10,080	10,561	10,587	9,216
Tract Pop.Density $< 200/Km^2$	625	285	242	238
Fraction of tract in group housing> 0.25	344	0	0	660
Fraction of "Other Race" in tract > 0.50	440	1,853	3,014	5,134
MSA population $<$ 1 Million	5,718	8,040	9,029	8,515
Frac. MSA population black < 0.10	8,427	9,626	9,722	9,394
Tract Sample Each Year	12,994	16,387	17,370	17,082
Plus tracts selected in another Year	781	1,015	696	301
Tract Sample	12,994	16,387	17,370	17,082

The sample includes the following 30 MSAs: Atlanta, Birmingham, Buffalo-Niagara Falls, Charlotte-Gastonia-Rock Hill, Chicago-Gary-Kenosha, Cincinnati-Hamilton, Cleveland-Akron, Columbus, Dallas-Fort Worth, Dayton-Springfield, Detroit-Ann Arbor-Flint, Greensboro-Winston-Salem-High Point, Houston-Galveston-Brazoria, Indianapolis, Jacksonville, Kansas City MO, Louisville, Memphis, Miami-Ft. Lauderdale, Milwaukee-Racine, NY-North New Jersey-Long Island, Nashville, New Orleans, Norfolk-Virginia Beach-Newport News, Orlando, Philadelphia-Wilmington-Atlantic City, Raleigh-Durham-Chapel Hill, St. Louis, West Palm Beach-Boca Raton, Washington-Baltimore.

residuals from these regressions by adding the mean of log average house value in each year in the Tract Sample. Exponentiate. The result is the measure of P_j employed.

Cleaning regressions for earnings and house prices include all tracts that were not empty or had missing variables (see Table A1). The reason for this choice is that the measures of (Y, R, P) outside the tract sample are used to measure residential mobility in Appendix A2.

A2 Residential Mobility

This appendix measures the intergenerational mobility of U.S. households across neighborhood types. The question to be answered is this: what is the probability that a household head of race r that grew up in a neighborhood type n, moves to a neighborhood type n' when adult? This is done in two steps. First, I construct a dataset tracking the location of individual households over time and classify those locations as being RN 1 or RN 2. To do this, I combine data on neighborhood type with panel data on the

bution of number of units in structure (5 categories), the distribution of year built (6 categories in 1970, 7 categories in 1980, 8 categories in 1990, and 9 categories in 2000), the distribution of the number of bedrooms in unit (6 categories), the fraction of tract units with complete plumbing facilities, and the fraction of units with complete kitchen facilities.

location of individual households. Household location data are from the PSID individual files together with the PSID geocode file, which indicate the Census tract of residence of each individual annually in years 1968-1996 and biannually in years 1997-2007.[42] A household is defined as any PSID individual that was ever a "head of household" or a "wife."[43] Each tract's type (1 or 2) in each year comes from the clustering procedure described in Section 4.1.1 for each year and geocoded location.[44] The intersection between Census tract and household-level information has to be maximized. To do this, I relax some tract selection criteria. In particular, I only apply the "Empty Tract / Missing Variables" criterion in Table A1. The classification as type 1 or 2 of tracts outside the tract sample is performed using the same criterion applied to the tracts within the tract sample in Section 4.1.1.[45]

Second, I calculate age-specific neighborhood-type transition matrices indicating the probability that a household of age j and race r moves from a neighborhood type n_j to a neighborhood type n_{j+25} in 25 years. A household is assigned to age group j if its reported age in the PSID lies in the interval $[j-2, j+2]$. The age-race cell sizes vary between 91 and $2,626$. The smallest cells correspond to white households in RN 1 (cell sizes vary between 91 and 152) and black households in RN 2 (cell sizes vary between 338 and 435). A period of 25 years corresponds to the duration of a model period, so that the frequency of the transition probabilities matches the model exactly. However, the age at which the probability should be measured is not clearly defined by the model. Fortunately, Figure 5 shows that transition probabilities do not vary dramatically with age, so the results will be robust to the choice of age. The age chosen is 10. This age roughly corresponds to the midpoint of a child's life with her parents. The endpoint of the measurement period corresponds then to age 35, roughly the midpoint of parenting life. Transition probabilities at this age are reported in the notes of Figure 5.

[42]The geocode files are available only with special permission from the PSID.

[43]In the PSID, white and black households come from two samples. The core sample was designed to be representative in 1968, while the Survey of Economic Opportunity sample was designed to oversample the poor. Both samples are used here to obtain reasonable sample sizes. Since the statistics reported condition on race and neighborhood, the distortion from this source is expected to be small.

[44]The NCDB is decennial as it is derived from the decennial Census. Therefore, tract type must be imputed in non-census years. The imputed tract type in non-census years is the type observed for the same tract in the closest census year.

[45]Classification of these tracts does not require reapplying the clustering procedure. One just calculates the distance of each out-of-tract-sample tract to the centroids of RN 1 and RN 2 in a particular year and classifies the tract as being of the "closest" type. See Section 4.1.1 for a discussion of centroids and the distance metric used.

A3 Distribution of Lifetime Household Earnings

This section uses the PSID core sample to construct the distribution of lifetime earnings by race used in the calibration. The first step is to construct annual household earnings as the sum of the total labor earnings of the head and spouse (if present). These variables are available in the PSID between 1968 and 1994. The sample satisfies the following selection criteria: The household head has between 25 and 45 years of age; the reported earnings of the head and of the spouse are consistent with reported hours of work; hourly earnings are above half of the current federal minimum wage for head and spouse (if present); and the households has at least 5 valid annual earnings observations. Annual household earnings are expressed in dollars of 2000 using CPI-U. A "clean" annual earnings measure is obtained by first extracting the residuals from a regression of annual household earnings against age and year dummies. Then the residuals are additively normalized to match earnings by race from Table 1. Finally, lifetime earnings are obtained by averaging "clean" annual earnings over all annual observations available for each household. The 5th, 10th, 25th, 50th, 75th and 90th percentiles and the variance of log household lifetime earnings are presented in Table 4 and Figure 6. In calculating these moments, a household's weight is proportional to its number of available annual observations. The total number of observations is 2,595 for white households and 285 for black households. The average number of observations available for a household range from 5 to 25 with an average of 14.3.

A4 Value of Parental Time Investments

The American Time Use Survey (ATUS) 2003-2009 is used to measure parental time investments by race.[46] ATUS data are collected through a 24-hour time diary kept by a random subsample of Current Population Survey (CPS) respondents. The time use category used here (variable BLS CARE HHKIDS) includes time spent in caring for and helping household children, activities related to children's education, and activities related to children's health reported as a primary activity.[47] The sample used consists of U.S.-born black or white persons between 25 and 64 years of age who have an own child

[46]Parental investments take diverse forms. In general, however, the early childhood literature has emphasized time intensive inputs. Some papers find that reading stories to the child, helping the child learn numbers, the alphabet, colors and shapes and for older children encouraging hobbies and taking them to museums and theaters are highly valuable parental inputs.

[47]For example, child care would not count as a primary activity when an individual reports watching television or washing clothes while "in the company" or "in care of" of a child. As in this paper, secondary activities are usually not considered investment in the parental time use literature. See Guryan, Hurst and Kearney (2008) for a discussion.

Table A2: Value of Time Invested in Children per Household

Race of Responding Parent	Black			White			Combined
Sex of Responding Parent	Male	Female	Joint*	Male	Female	Joint*	Joint†
(a) Time per child	0.34	0.66	0.78	0.58	1.04	1.49	1.34
(b) Average wage of workers	16.34	13.53		21.64	17.03		
(c) Children per household	1.98	1.97		1.97	1.94		1.98
(d) Parents per household	0.49	0.94		0.86	0.96		
Value††	3,989	6,402	7,965	8,977	12,506	19,688	17,226
Observations	641	1,769		9,447	13,220		

*Combines male and female inputs using weights in (d) to obtain a representative household.
†Weights for each race come from the fraction of white and black households in Table 1.
†† Value of input per household is given by $(a) \times (b) \times (c)$.

at home. Individuals with inconsistent total time allocations or inconsistent earnings and hours of work are excluded from the sample.[48] Average time spent in children is calculated using the weights provided (variable WT06) to account for the sample design, which oversamples weekends.

A problematic aspect of the ATUS is that time use is available for only one individual from each household. This complicates the estimation of household-level statistics from these data. The issue is handled here by focusing exlusively on means. Separate means for household heads and their spouses are obtained from the data. Means of household-level aggregates are then estimated by aggregating head and spouse means.

Table 3 displays time investment per child, average wage, and average number of children for parents of each race and each gender. For each race and gender, the total value of time investments in children is obtained as the product of time investment per child, total number of children and average wage. For each race, the value of investments per household is obtained by adding the value of investment of male parents, times the number of males per household, plus the value of investments of female parents times the number of female parents per household.

There is a substantial black/white gap in this simple measure of parental inputs. Part of the gap comes from differences in time investments per person which vary from 0.34 hours by black males to 1.04 hours by white females. Another part comes from differences in the value of time, which varies from 13.53 dollars per hour for black females to 21.64 dollars per hour for white males.[49]

[48]Total time allocation is inconsistent if total time allocated per day is not equal to 24 hours. Hours of work and earnings are inconsistent according to the same criteria used with Census data.

[49]Selective labor force participation is not taken into account in these calculations as the wages are

A5 Definition of the Transition Function

Let $\mathcal{A}$ denote a subset of interval $[0, \overline{h}]$. Then define the transition function as:

$$P\left((h,z,r),(\mathcal{A}_h,z',r)\right) \equiv \pi_{zz'} \sum_{n=1}^{N} \eta\left(n|(h,z,r)\right) 1(h\left((h,z,r),n\right) \in \mathcal{A})$$
$$h\left((h,z,r),n\right) \equiv F(z, hl((h,z,r),n), Y_n).$$

A6 Computing Stationary Equilibria

1. Guess the vector of perceived neighborhood characteristics $\{(Y_n, R_n, P_n)\}_{n=1}^{N}$

2. Solve the household's decision problem given the starting values from (1) using value function iteration.

3. Use the optimal decision rules to approximate the stationary distribution μ. For $n = 1, 2$, compute the values of $\widehat{Y}_n, \widehat{R}_n, \widehat{D}_n$ implied by the approximate stationary distribution.

4. If $Y_n \approx \widehat{Y}_n$ and $R_n \approx \widehat{R}_n$ and $L_n^0(P_n^0)^\zeta \approx \widehat{D}_n$ terminat.[50] Otherwise, update human capital, racial configuration and housing prices, and go back to step (2).

computed from the subsample of workers. Controlling for selective labor force participation would presumably imply a larger gap in the value of parental inputs.

[50]The approximation error margin allowed for each of these conditions was 0.00005.