The Black-White Lifetime Earnings Gap

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Abstract

In the early 1900s, white males earned 3.4 times more income over their lifetime than Black males. This gap is twice as large as the more commonly studied cross-sectional Black-white earnings gap because 48% of Black males born in 1900 died before the age of 30 as compared to just 26% of white males. Economists often use cross-sectional earnings to measure inequality between groups, but a more complete measure of inequality combines income profiles and mortality risk into a unified measure of welfare. This method is especially important in historical contexts, where mortality rates often vary substantially across groups and over time. We calibrate a model of optimal consumption in a world with mortality to data describing the lifecycle earnings and life expectancy of Black and white males born between 1900 and 1970. Using this model, we find that convergence in Black and white mortality rates led to a 50% reduction in Black-white welfare gaps between the 1900 and 1920 birth cohorts, even as cross-sectional Black-white income gaps for those cohorts remained relatively constant. But, the Black-white welfare gap remained large and unchanged from the 1920 to 1970 birth cohorts as gaps in Black-white life expectancy and income stagnated.

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The views we express in this paper are we own and do not necessarily reflect the views of the Federal Reserve Bank of Chicago or the Federal Reserve System.

Introduction

Economists often use repeated cross-sections of income and wealth inequality to measure changes in inequality over time (Piketty, 2003; Piketty and Saez, 2003; Anand and Segal, 2008; Derenoncourt et al., 2022). But cross-sectional measures of inequality can provide a misleading measure of inequality in outcomes between groups because of mortality. When social scientists estimate economic parameters using cross-sectional data, death acts as a form of sample selection. Consider the measurement of income inequality for two demographic groups (A and B). If unequal access to healthcare caused a randomly selected 20% of the people in group A (but not B) to die before age 30, and sharp improvements in healthcare access suddenly reduced to zero that gap in mortality, standard measures of cross-sectional income inequality would not change due to the increase in healthcare access.[1] But the increase in life expectancy clearly had large effects on relative welfare for each group.

Many economists recognize that death is a form of sample selection when measuring welfare. For example, Kanbur and Mukherjee (2007) construct measures of poverty that account for the "glaring paradox in all commonly used measures of poverty. The death of a poor person, because of poverty, reduces poverty according to these measures."[2] While many researchers inherently address this concern by proposing measures of inequality based on a birth cohort's adult outcomes, they often follow those proposals by instead calculating inequality cross-sectionally, ignoring members of the studied birth cohorts who are no longer in the sample due to death. In one of the first papers that used census microdata to analyze Black-white inequality, Smith and Welch (1989) study cross-sectional Black-white gaps in educational attainment and earnings for adults in the census, claiming that "[a]mong men born in this century, there has been a substantial

[1] This example ignores any general equilibrium effects for the sake of exposition.

[2] Currie (2011) makes a related argument: "A possible drawback to using data on births [to measure welfare effects of pollution abatement] is that pollution could affect the probability of a conception or of a live birth. If we suppose that pollution abatement would lead to fewer fetal deaths, and more births, and that the marginal fetus lost due to pollution is more vulnerable and less healthy than others, then focusing on births will tend to understate the beneficial effects of abatement by increasing the number of less healthy infants whose birth weight is recorded."

narrowing of racial difference in years of school completed." But Smith and Welch focus only on those Black and white men alive in later censuses as adults, ignoring the large number of men with low levels of education who died before they could be enumerated in decennial censuses.

In this paper, we explore the importance of mortality in the measurement of inequality in the context of Black-white earnings gaps. We choose this case to illustrate the importance of mortality in measuring inequality because of large changes in Black-white income and mortality gaps over this time period. For example, Bayer and Charles (2018) show that the Black-white gap in median income shrank from roughly 1 log point in 1940 to 0.66 log points in 1950 before stagnating from 1950 to 2014.[3] And earlier work by Card and Krueger (1993) states that "The narrowing of the Black-white earnings gap between 1960 and the mid-1970's represents one of the most significant episodes of relative progress for African Americans in U.S. history." Cross-sectional earnings gaps represent differences in the relative price of available white and Black labor in a given year, and that is itself a potential outcome of interest in discussions of discrimination and inequality in the labor market. But economists and policymakers often point to these trends as measures of the relative life outcomes of Black and white men. A more complete way to think about inequality between birth cohorts is to start at birth and measure the lifetime outcomes for these groups. From this starting point, mortality is important.

A set of papers approaches the welfare effects of increasing life expectancy by considering the economic value of health improvements. Murphy and Topel (2006) use a structural model of health and labor decisions to estimate that increases in life expectancy since 1900 were worth trillions of dollars to society. In related work, Murphy and Topel (2005) show that increases in life expectancy since 1968 were worth more for Black men than they were for white men. And Becker et al. (2005) and Gallardo-Albarran (2019) measure cross-country inequality by combining GDP and life expectancy to construct a measure of "full income." Becker and his co-authors shows that cross-country inequality shrank significantly between 1960 and 2000 when they measure inequality

[3]See Figure 9A in Bayer and Charles (2018).

using this combined 'full income' metric. Gallardo-Albarran uses a similar method to show that GDP-based measures of welfare understate cross-country improvements in living standards in the early 1900s.

In this paper, we provide the first long-run estimates of lifetime earnings by race in the United States. Researchers have used administrative datasets to calculate lifetime earnings in Germany, Norway, and the United States (Bonke et al. 2015; Bhuller et al. 2017; Tamborini et al. 2015; Guvenen et al 2017). But researchers have only separated out lifetime earnings estimates by race using synthetic cohorts from more recent time periods[4]. After we calculate lifetime earnings by race, we construct a 'full income' measure of welfare based on income, life expectancy, and a structural model of optimal consumption. We use this model to discuss trends in Black-white inequality in the 20th century. The theoretical component of our paper relates to recent work by Brouillette, Jones, and Klenow (2021), who calculate Black-white welfare gaps over time, with a focus on a more recent period (1984–2019), and find substantial convergence in Black and white welfare using a model that accounts for life expectancy, consumption, leisure, and inequality.

In the following sections, we describe the census microdata that we use to estimate life expectancy and earnings measures. We use this data to calculate and compare cross-sectional Black-white earnings gaps and lifetime earnings by birth cohort. We then put an economic value on the Black-white life expectancy gap for each birth cohort using research from the literature on how to calculate the value of a statistical life (VSL). We propose a simple structural model of optimal consumption where newborns with different types face known exogenous sequences of mortality risk and income each year. We calibrate this model using Census data and show that declining mortality risk for Black children between 1900 and 1940 halved the Black-white welfare gap. Convergence then slowed, and a significant Black-white welfare gap still exists; this gap is driven by persistent Black-white gaps in both earnings and mortality rates.

[4] For example, Table 4-2 of Jena, Philipson, and Sun (2010) examines lifetime race-based earnings gaps from 1970–2000.

Data

Census Microdata

We use the 1910-2010 public-use decennial census and 2006-2014 American Community Survey microdata from IPUMS to estimate earnings gaps by race and birth cohort (Ruggles et al. 2020).[5] These data represent cross-sectional nationally representative samples of the U.S. population every ten years from 1910-2000 and annually from 2006-2014. For all the analyses described below, we subset to Black and white men born in the U.S. between 1900 and 1970. We use sample weights throughout so that our estimates are nationally representative of the American-born Black and white populations.

We use the census microdata to calculate three separate measures of annual earnings: labor earnings, post-tax labor earnings, and total earnings. We start with labor earnings from 1940-2014 and total earnings from 1950-2014. In 1940, only labor earnings are available.[6] In all years, we assume that all males have zero earnings before the age of 16, because these younger men were often not in the sampling frame of the decennial census's income questions.[7] Because no earnings measures are available before 1940, we must first calculate earnings for males before 1940 so that we can estimate lifetime earnings for the 1900-1970 birth cohorts. We begin by estimating non-labor earnings for each male in the 1940 census using data from 1950. We regress 1950 non-labor earnings at the individual level on indicators for race, age, occupation, industry, state of birth, and

[5]We do not use data from the 2001-2005 ACS because the 2001-2005 ACS do not include institutionalized individuals in their sampling frames. We also do not use the 2015 and 2016 ACS data because the Census Bureau modified the race variable in those years, complicating comparisons between pre-2015 data and 2015-2016 data.

[6]Also, in 1940 1.5% of respondents were institutionalized and these respondents were not asked to report labor income. We assume that all of these respondents have zero earnings, but that does not affect any of this paper's conclusions.

[7]Males under the age of 16 had very low measurable earnings in the early 1900s. According to Table 2 of the U.S. Census of Manufacturers report on the Earnings of Wage-Earners, less than 1% of total earnings were paid to workers under the age of 16. While this evidence is from only one (large) sector of the economy, anything close to a 1% change in the total earnings of any group in we sample will not affect, in any way, the conclusions of this paper. Source: `https://catalog.hathitrust.org/Record/008433603`

state of residence.[8] we then use these regression coefficients to predict non-labor earnings for each male in 1940.[9]

At this point, we have measured labor and total income for 1940 onward. We calculate post-tax earnings by merging federal individual personal income tax rates and personal exemption amounts from the appropriate year onto each individual in the 1940-2014 census and ACS data. We apply these tax rates and personal exemptions to each person's nominal labor earnings to estimate each person's post-tax earnings. We rely on federal income tax rates and not state or local income tax rates for two reasons. First, there is no standardized time series of state income tax rates in the early or mid 1950s.[10] Second, federal income taxes are the largest source of income tax revenue. For example, in 2015, federal, state, and local personal income tax revenue totaled 1.5 trillion dollars, 336 billion dollars, and 32 billion dollars respectively.[11]. The disparity between federal and non-federal income tax revenue was even larger in the 1900s.

We inflate all earnings variables to 2015 dollars using the CPI-U. To estimate the earnings of men pre-1940, we use the same imputation procedure that we used to impute 1940 non-labor earnings. We regress 1940 labor, total, and post-tax earnings for people in we sample on indicators for race, age, occupation, industry, state of birth, and state of residence. We use these regression coefficients to predict the amount of earned income for all men in decennial years 1910, 1920, and 1930.

[8]There are roughly 300 distinct occupations and 20 distinct industries in the census microdata. We also separately regress an indicator for whether or not each person worked on those indicators and included the predicted value from that regression in the wage regression.

[9]Census earnings data is topcoded, and that topcoding often effects 0-2% of all observations. In the tables we present in this paper, we do not correct for this topcoding, but it has no effect on any of our results. To confirm that this is the case, we replicate the main results from this paper by assuming that the income distribution in each year closely matched the income distribution in 2000, when topcoding had a negligible effect on reported income. For example, in 1950, which has the most topcoding of any census year, roughly 2% of labor income valaues are topcoded. So, we see that in 2000 the 98th percentile of the labor income distribution was roughly $190,000. The average of income values in the top 2% of the 2000 income distribution is roughly $300,000, so we multiply all topcoded income values in 1950 by $\frac{300000}{190000} = 1.6$. In 1960-1990, the topcoding 'ratio' is around 1.15.

[10]One working paper attempts to construct a federal and state income tax calculator, but the calculator is incomplete and not yet available to researchers (Bakija 2017).

[11]See https://www.taxpolicycenter.org/statistics/revenue-government-level

We then collapse the census microdata into estimates of the average income for each age*year*race cell. We linearly interpolate these income averages for each age*race cell in years between adjacent census years.[12] For example, we take the average income of white 16 year olds in 1940 and 1950, and linearly interpolate average incomes of white 16 year olds for the years 1941-1949. We also linearly interpolate population counts for each age*race cell across missing years. Because pre-1940 earnings information was based on the relationship between 1940 demographic information and earnings, we lastly multiply all pre-1940 earnings cells by the ratio of average earnings per person in that year to average earnings per person in 1940.[13] In a small number of sparsely populated cells describing respondents at young ages, the imputed earnings are very slightly negative. In those cases, we zero out the earnings in that cell.

Life Expectancy Data

We calculate the number of Black and white men born in the U.S. in each year between 1900 and 1970 using CDC summary tables and Census microdata. The CDC publishes U.S. birth counts separately for Black and white males from 1959-present and for white and non-white males from 1910-1959.[14] The CDC also produces the probability of surviving through age $t \in \{1, 5, 10, 15, ..., 100\}$ for Black and white men in decennial census years from 1900 to the present.[15]

[12]Each age*race cell has roughly ten snapshots of census and ACS data that we use to interpolate income values. Our results are virtually identical when we interpolate income data using more flexible cubic splines.

[13]Source: Series D722-727 on page 44 of the Labor section in the U.S. Census Bureau's 1970 Historical Statistics of the United States, Colonial Times to 1970. See `https://www2.census.gov/library/publications/1975/compendia/hist_stats_colonial-1970/hist_stats_colonial-1970p1-chD.pdf` for more details about how the series was constructed.

[14]We rely on birth counts separated by the race of the child when available (not the race of the mother). See Table 1-1: Live Births, Birth Rates, and Fertility Rates, by Race: United States 1909-2000. See `https://www.cdc.gov/nchs/data/statab/t001x01.pdf`. The CDC data described here rely heavily on birth and death certificates.

[15]See Table 20 of Arias (2011). The CDC constructs these survival probabilities using census data, medicare records, and birth and death certificates. CDC mortality rates for 1900 and 1910 rely on a smaller number of 10 death registration states that collected complete vital statistics information. And mortality data for 1920 rely on 34 states with high-quality data. Black births were underreported in the early 1900s because of the CDC's reliance on death registration states and because of poor birth certificate quality. This in turn biases Black infant mortality rates. Eriksson, Niemesh, and Thomasson (2018) show that Black infant mortality rates are biased upward relative

We use census microdata to construct a measure of birth counts to validate the CDC mortality rates. In Figures 1 and 2, we plot the number of white and Black males born each year from 1900 to 1970. The CDC datapoints are the raw birth counts from the CDC. In years prior to 1959, we assume that the number of non-white non-Black births equals 55,000, which is the number of non-white non-Black births in 1959.[16] The imputed datapoints take the CDC survivorship rates, linearly interpolate them to fill in years and ages without available data, and apply them to the counts of people in the census and ACS microdata in the appropriate birth cohort, race, and age group. This produces implied birth counts from each age*birth cohort*race cell in the census microdata. Figures 1 and 2 show the median number of implied births from cells aged 5-60 in the census.[17] The survivorship rates provided by the CDC, applied to Census counts closely match the CDC birth counts. Although the CDC birth counts do tend to be roughly 5% larger for both Black and white males.

As readers can see in Figures 3 and 4, Black males had significantly shorter lifespans than white males in the early 1900s. In Figure 3, we plot Black and white life expectancy for males by birth cohort using each year's age-specific mortality rates. The life expectancy numbers in this figure come directly from the CDC and rely on a variety of statistical procedures to identify true life expectancy (Arias, 2011). White males born in 1900 had an average life expectancy at birth of 47 years and Black males born in 1900 had an average life expectancy at birth of 33 years. Note the sharp drop in life expectancy for the 1918 white and Black birth cohorts. This drop is due to

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to white infant mortality rates because Black newborns are less likely to be enumerated by government agencies. For example, in 1940 94% of white births were registered on birth certificates, while only 82% of Black births were registered on birth certificates, which is consistent with earlier work showing that Black births were undercounted on birth certificates by roughly 20% in 1880-1940 (Coale and Rivers, 1973). Eriksson and coauthors argue that the Black infant mortality rate for the 1915 birth cohort was 11.1%. Meanwhile, the CDC data (Arias 2015, Table 20) implies a Black infant mortality rate of roughly 14.9%. While this difference is quantitatively large, our estimates of lifetime earnings gaps are largely driven by death rates before the age of 20. And this 3.8pp mortality rate underestimation is not quantitatively important for our welfare estimates when compared to the probability of death before the age of 20, which was roughly 29% for the 1915 birth cohort of Black males.

[16]We rely on this assumption in years before 1959 when the CDC did not separate out births of Black children from births of all non-white children.

[17]We subset to these age ranges because in ages 0-4 and 61+, census population counts have various rounding, undercounting, and small sample size issues in some years.

the Spanish Flu, which single-handedly decreased life expectancy by 11.8 years in 1918 (Noymer and Garenne 2000).[18] Life expectancy increased dramatically between the 1900 and 1940 birth cohorts, and the Black-white gap in male life expectancy shrank from 14.1 years to 10.6 years. In Figure 4, we plot the probability of surviving through age 30 by race and birth cohort using actual mortality rates experienced by these birth cohorts, through age 30. We can see that the largest convergence in life expectancy took place between the 1900 and 1920 birth cohorts.

Cross-Sectional Earnings Gaps

In Table 1, we report the average earnings of living Black and white 30 year-old men every ten years, beginning in 1930 and ending in 2020.[19] we inflate the earnings values into 2014 dollars using the CPI-U. We do not subset to wage-earners, so men with no earnings are included in the average. The 1930 through 2020 years of data in Table 1 correspond to the 1900 through 1990 birth cohorts. White earnings roughly double over this time period while Black earnings roughly triple. The ratio of white to Black average earnings at age 30 increases from 1930 to 1940 before declining between 1940 and 1950 and declining slowly in the following years. Post-tax labor earnings (column 2 of each panel) have a slightly smaller white/Black earnings ratio for the simple reason that income tax rates in the U.S. are progressive and white males had higher average incomes than Black males. Total earnings, which includes government transfers, investment, and other income, display similar trends to labor earnings. Table 1 shows that white males born in 1900 who were living at age 30 earned an average of 2 times the amount that living Black males born in 1900 earned at age 30.

In Figure 5, we plot the ratio of white to Black labor earnings for living men in different age

[18]This 11.8 year drop in life expectancy in Figure 3 is based on a cumulation of the age-specific decreases in life expectancy for Americans in 1918. In other words, males born in 1918 did not have a realized lifespan 11.8 years lower than males born in 1917. But if one had given ever male born in 1918 the age-specific mortality rates of cohorts in 1918 as they proceeded through life, the projected life expectancy of males born in 1918 would have been 11.8 years lower than the projected life expectancy of males born a year earlier.

[19]We impute earnings for the pre-1940 and post-1914 years using the methods described in the data section.

groups to better visualize the evolution of cross-sectional white earnings relative to Black earnings over time.[20] The figure separates out this ratio for living men in each birth cohort and in three age bins: men in their 30s, 40s, and 50s. To produce each line, we average the ratio of white to Black earnings for each age in that group. Recall that we impute data in non-decennial census years before 2000. Also, for the 1975 birth cohorts and the men in their 50s, the white/Black earnings ratio is projected forward in years that have no available data (2015-2029). In Figure 5, the white/Black average earnings ratio is roughly 2 for the 1900 birth cohort in each age bin. The gap steadily drops to around 1.7 in the 1945 birth cohort before slowly increasing back up to 1.8-2.1 depending on the age bin. If we used this type of standard inequality metric as a measure of the evolution of Black-white inequality for children born in different years, we might assume that there was no progress in the expected adult labor market outcomes of white men relative to Black men between 1900 and 1970. But as we discussed above, this is misleading.

Lastly, in Figure 6 we show how the ratio of white to Black labor earnings evolves over the life-cycle for four different birth cohorts from 1900 to 1975. For more recent cohorts, we impute data for later ages. The plot is noisy, because the sample sizes for a specific birth cohort*age*race cell are not particularly large (especially for Black males), but the general trend is that the relative earnings of white relative to Black males increases from 1.5 at young ages to closer to 2 at higher ages.

Lifetime Earnings Gaps

We construct estimates of lifetime earnings for each birth cohort and race using the decennial census and ACS microdata described in the data section, imputing earnings for unavailable years and ages. In addition, to estimate lifetime earnings for more recent birth cohorts, we assume that real earnings will grow for each birth cohort*race group at a 1.5% rate from 2014 through 2060.

[20]The graphs for post-tax labor earnings and total earnings are virtually indistinguishable and show all the same trends.

We also assume that no one earns any income after age 89. We calculate two measures of lifetime earnings: undiscounted and discounted. For the discounted lifetime earnings, we discount each annual income datapoint back to the birth year for each cohort (assuming an annual discount rate of 0.96). We then sum the average earnings from age 16-89 for each race in each birth cohort, weighted by the interpolated CDC mortality rates. This is a measure of the 'expected' earnings for each birth cohort, if the men in that birth cohort only knew their race, expected annual income at each age conditional on race, and expected annual mortality rates conditional on race, with no other information about ability or environment.

In the previous section, we calculated cross-sectional earning gaps, which are standard and reported widely in the literature on Black-white inequality. We now provide the first estimates of lifetime earnings for birth cohorts in the U.S. In Table 2, we report the average undiscounted lifetime labor earnings, lifetime post-tax labor earnings, and lifetime total earnings for Black and white birth cohorts born every five years from 1900 to 1970. In Table 3, we report discounted lifetime earnings ($\beta = 0.96$). Lifetime earnings roughly tripled for white men and increased by a factor of six for Black men when we compare the 1900 and 1940 birth cohort. But lifetime earnings then increased only slightly from the 1940 to 1970 birth cohorts. The 'No Death' column reports the lifetime earnings each newborn male could expect to receive in the given cohort if they died at age 90 and received the average earnings for the living males in their birth cohort*race cell at each age. As expected, the hypothetical lifetime earnings in a world with no death are roughly 45-50% larger for white males than their actual average lifetime earnings. For Black males, the hypothetical lifetime earnings in a world with no mortality until age 90 are 2.3-2.6 times larger than the actual lifetime earnings.

We also include, in Tables 2 and 3, a column titled "+VSL" that column measures the economic value of the difference in life expectancy for each birth cohort of Black and white men. We calculate this value as follows: we begin with a $2.2 million estimate of the value of a statistical life for the 1970 birth cohort.[21] we follow the U.S. government in assuming that the value of a statistical life year is constant across ages and races (Aldy and Viscusi, 2008). Because the lifetime income and life expectancy of the average male born in the U.S. grew tremendously between 1900 and the present, we scale our estimate of the VSL by the changes in lifetime income and the changes in life expectancy each year. To do this, we first assume that the $1.5 million estimate comes from the 1970 birth cohort. White males born in 1970 had a life expectancy of 68 years. So, the 1970 birth cohort of white men valued each life-year at around $32,000 2015 dollars, which is 0.074-times their discounted lifetime earnings of $432,000. So, we use 0.074*(the average lifetime earnings of white men) as a measure of the value of a statistical life year for each birth cohort. This means that the statistical value of a life year increases as the average lifetime income of men grows. Here, we am assuming that a 1% change in lifetime income increases the statistical value of a life-year by 1%. This is not unrealistic, since recent estimates of the income elasticity of the value of a statistical life year range from 0.7 to 1.1 (Viscusi and Masterman, 2017).

In Tables 4 and 5, we report the ratio of white to Black undiscounted and discounted lifetime earnings, for all three measures of earnings (labor, post-tax labor, and total earnings). We also report in the 'No Death' column what the ratio of white to Black lifetime earnings would be in a world where everyone lived through age 89 and died at age 90. White males born in 1900 earned roughly 3.4 times as much over their lifetime as Black males born in 1900 did. This ratio fell to 2.1 for the 1920 birth cohorts and has since fallen only slightly further, to 2.0 for the 1970 birth cohort. The last column in each panel of Table 3 presents the ratio of white to Black expected consumption from the model we present in the next section.

[21] Ashenfelter and Greenstone (2004) use changes in speed limits to estimate the causal effect of a change in mortality risk on time saved. By putting a value on each hour of travel time saved equal to the average hourly wage, they estimate that the value of a statistical life is $1.5 million in 1997 dollars, which is $2.22 million in 2015 dollars. Recent papers by Ioannidis et al. (2017) and Doucouliagos, Stanley, and Giles (2012) show that standard hedonic measures of the VSL suffer from "severe publication selection bias." The authors correct for this publication bias by conducting a meta-analysis of the VSL parameter after restricting to studies with a sufficient amount of power. They estimate a VSL of $1.47 million in 2000 dollars, which is virtually identical to the estimate of the social value of a statistical life from Ashenfelter and Greenstone (2004).

It is clear that white men born in the early 1900s had significantly higher lifetime earnings than equivalent cohorts of Black men. But white men could also expect to live much longer than Black men in all birth cohorts. One simple way to combine both of these facts into one welfare metric is to add the value of the additional life-years that white males could expect to receive at birth to their lifetime income. The thought experiment here is that if white and Black males could all expect to live for the same number of years, but still expected to receive the lifetime earnings of their respective race*birth cohort, then the white birth cohort should be indifferent between receiving X additional years of expected life or receiving a lump sum payment at birth equal to the value of a life-year from the VSL literature times X. In Table 2, we presented this value of the Black-white gap in life expectancy for each birth cohort in the '+VSL' column.

In the third column of each panel in Table 3, we take the ratio of white lifetime earnings + the value of the extra years of life white cohorts received to Black lifetime earnings. In Figure 7, we plot these six measures of relative white and Black welfare annually. This method for combining lifetime earnings and life expectancy gaps into one welfare measure is useful because it is in dollars, but it is somewhat ad hoc. We must assume a fixed value of each year of life for a given birth cohort, independent of how long they live and independent of their annual income profile; in other words, there are no decreasing returns to life expectancy and there is no interaction between the return to additional income and the return to lower mortality risk. So, below we calibrate a simple model of consumption in a world with mortality risk to the census data.

Model

We consider a simple model of optimal consumption in a world with annual mortality risk. Time is discrete with T periods, $1,\ldots,T$. Each person born in year 0 plans to consume c_a at each age a if they are alive, which provides them with utility at age a of $u(c_a)$. p_t is the independent and exogenous probability that a person dies at age t, so the probability of surviving through age

a is $s_a = \prod_{j=1}^{a}(1-p_j)$. Earnings at each age a, $y_a \geq 0$, are exogenous and expected lifetime utility, given a sequence of consumption $\{c_a\}$, is

$$U = \sum_{a=1}^{T} \beta^a s_a u(c_a)$$

where β is the standard discount rate.

At birth, people can sign contracts to borrow or loan money intertemporally at a constant annual interest rate r. So the budget constraint is: $\sum_{a=1}^{T} \frac{s_a c_a}{(1+r)^a} = \sum_{a=1}^{T} \frac{s_a y_a}{(1+r)^a}$. In other words, a person can sign a contract to borrow against future expected income to finance consumption, but she can only borrow against income that the lender expects her to receive given the commonly known probability of dying each period and the commonly known income process. This budget constraint assumes a complete annuities market. Readers can think of this market as one where each newborn agrees to send their income each year to the bank, and in return, they receive a predetermined amount of money from the bank each year that they are alive. The amount of money the bank sends each person is governed by the consumer's budget constraint, which states that the lifetime net present value of consumption must be no larger than the lifetime net present value of income. This is equivalent to a zero profit constraint for the bank that is borrowing and loaning money, so this is a world where many small banks compete in this annuity market with exogenous interest rate r.

At birth, each newborn chooses a potential sequence of consumption $\{c_1 \dots c_T\}$ to maximize expected lifetime utility subject to the budget constraint. Consumption here is the total number of dollars the newborn will consume in a given period if they are alive. So expected consumption in period t is $s_t c_t$. The Lagrangian for this maximization problem is:

$$\mathscr{L} = \sum_{a=1}^{T} \beta^a s_a u(c_a) + \lambda \sum_{a=1}^{T} \left(\frac{s_a(y_a - c_a)}{(1+r)^a} \right)$$

Differentiating with respect to c_t gives us a sequence of first order constraints that yield the standard Euler equation: $\beta(1+r) = \frac{u'(c_t)}{u'(c_{t+1})}$. For simplicity, assume that $u(c) = log(c)$. So the Euler equation simplifies to $c_{t+1} = \beta(1+r)c_t = [\beta(1+r)]^{t-1}c_1$. The logic follows identically if utility is CRRA, but it is more difficult to solve for a closed-form value of consumption each period.

Going back to the budget constraint, and plugging in the Euler equation from the previous step, we can see that

$$\sum_{a=1}^{T} \frac{\beta^{a-1} s_a c_1}{1+r} = \sum_{a=1}^{T} \frac{s_a y_a}{(1+r)^a}$$

So,

$$c_1 = \frac{\sum_{a=1}^{T} \frac{s_a y_a}{(1+r)^{a-1}}}{\sum_{a=1}^{T} s_a \beta^{a-1}}$$

This means that $\forall t$,

$$c_t = \frac{[\beta(1+r)]^{t-1} \sum_{a=1}^{T} \frac{s_a y_a}{(1+r)^{a-1}}}{\sum_{a=1}^{T} s_a \beta^{a-1}}$$

We can now calculate, at birth, the amount each person expects to consume at each age as a function of known parameters. So, we can deterministically calculate the utility a newborn can expect to receive given (1) constant parameters β and r, and (2) a sequence of probabilities of dying at each age $\{p_a\}$ and income at age a, $\{y_a\}$. Notice that T is the lowest age a such that $p_a = 1$. Because the decennial census sometimes topcodes age at 90, we will assume that everyone dies by the age of 90, and therefore no one consumes anything after age 89.

We can now compare the expected utility of Black and white males over time and within a birth cohort by calculating levels of utility separately for Black and white newborns with known annual incomes (from census microdata) and probabilities of dying (from the CDC).

1 Comparative Statics

We can easily see that consumption in all periods is increasing in income, but the effect of mortality risk, p_a, on consumption in each period is more complicated. With many applications of the chain rule, we arrive at this partial derivative of consumption in period t conditional on being alive (c_t) with respect to the probability of dying (p_s) in a given period $s > 1$:

$$\frac{\partial c_t}{\partial p_s} = \frac{[\beta(1+r)]^{t-1}}{(1-p_s)} \left(\frac{\left(\sum_{a=1}^{s-1} \frac{s_a y_a}{(1+r)^{a-1}}\right)\left(\sum_{a=s}^{T}[s_a \beta^{a-1}]\right) - \left(\sum_{a=s}^{T} \frac{s_a y_a}{(1+r)^{a-1}}\right)\left(\sum_{a=1}^{s-1}[s_a \beta^{a-1}]\right)}{\left[\sum_{a=1}^{T} s_a \beta^{a-1}\right]^2} \right)$$

This partial derivative can be either positive or negative depending on the distribution of earnings and mortality over a lifespan. While this might seem unrealistic, recall that c_t does not represent realized consumption at age t. Instead, it represents consumption at age t if the representative agent lives to age t.

Using the partial derivative $\frac{\partial c_t}{\partial p_s}$, we can once again use several applications of the chain rule to calculate how utility is affected by an increased probability of dying in a given period.

$$\frac{\partial U}{\partial p_s} = \frac{1}{(1-p_s)} \sum_{t=1}^{T} \beta^t s_t \left(\frac{\left(\sum_{a=1}^{s-1} \frac{s_a y_a}{(1+r)^{a-1}}\right)\left(\sum_{a=s}^{T}[s_a \beta^{a-1}]\right) - \left(\sum_{a=s}^{T} \frac{s_a y_a}{(1+r)^{a-1}}\right)\left(\sum_{a=1}^{s-1}[s_a \beta^{a-1}]\right)}{\left(\sum_{a=1}^{T} \frac{s_a y_a}{(1+r)^{a-1}}\right)\left(\sum_{a=1}^{T} s_a \beta^{a-1}\right)} - log(c_t) \right)$$

Note that this sum is made up of two terms. The first term, a complicated ratio of terms, is bound below by -1 and above by 1. So a sufficient, but not necessary condition for $\frac{\partial U}{\partial p_s} < 0$ is if, $\forall t$, $log(c_t) > 1$. The reason this partial derivative can sometimes be positive is because if consumption is sufficiently close to zero, utility is negative, so an increase in the probability of dying actually increasing expected utility by moving it closer to zero. But for any plausible sequence of income, including all sequences of income we see in census microdata for race*birth cohort cells, this partial derivative will be negative; and an increase in mortality risk reduces utility.

Lastly, one value of this model is that it allows mortality risk to affect people differently as a function of their expected annual income. Equivalently, shocks to income will have different effects on people with higher or lower mortality risk. To measure this, we can calculate the cross partial derivative of c_t with respect to p_s and y_s, and we see that:

$$\frac{\partial c_t}{\partial y_s \partial p_s} = \frac{\beta^{t-1}(1+r)^{t-s} s_s}{(1-p_s)\left(\sum_{a=1}^{T} s_a \beta^{t-1}\right)^2} * \left[-\sum_{j=1}^{s-1} s_j \beta^{j-1}\right]$$

This is always negative, which means that at higher values of income, an increase in mortality risk in a given period has an increasingly negative effect on the level of expected consumption in all periods.

2 Calibration

We can now calibrate this model separately to any sequence of annual survivorship probabilities and earnings. We take each Black and white birth cohort from 1900 to 1970 and calculate expected consumption and utility for that cohort. In Table 4, Table 5, and Figure 7, we show the ratio of dollars of lifetime expected consumption for white and Black birth cohorts each year. These closely match the general time trends of we earnings-based inequality measures, with the largest convergence in expected lifetime consumption between the 1900 and 1920 birth cohorts. But this measure of relative consumption calibrated to total earnings (in the last column of Table 4) shows continual gradual progress in Black-white inequality between the 1920 and 1970 birth cohorts.

In Figure 8, we plot the level of utility for Black and white males in each birth cohort. Normally levels of utility are unitless and not particularly understandable. But in this model, levels of utility represent the net present value of future expected log consumption. As we can see in Figure 8, levels of utility have weakly monotonically increased from the 1900 to 1970 birth cohorts for Black and white males. In Figure 9, we plot the gap between Black and white utility levels. The largest convergence in Black and white utility occurred between the 1910 and 1920 birth cohorts. Since then, the gap is roughly constant. Black males born in 1970 have earnings and mortality risk that net them welfare equivalent to the welfare received by white males born in 1930.

3 Conclusion

48% of Black males born in 1900 died before the age of 30 as compared to only 26% of white males. These mortality rates declined to 22% and 15% by the 1920 birth cohort, and this sudden convergence had large effects on relative welfare. Black-white cross-sectional earnings gaps are often used as a measure of inequality, but these gaps ignore the large (albeit incomplete) convergence of Black and white mortality rates from 1900 to the present. We calculate two 'full income' measures of Black-white inequality that combine lifecycle earnings and mortality rates to measure welfare.

In the 1940 census, the average working-age white male reported earnings twice as large as the average working-age Black male. But because Black males had significantly higher mortality rates at each age, white males born in 1900 could expect to have lifetime labor earnings 3.4 times the lifetime labor earnings of Black males born in 1900. This ratio fell to 2.1 in the 1920 birth cohorts and has since fallen only slightly further, to 2.0 for the 1970 birth cohort. A simple structural model of consumption in a world with mortality risk similarly shows that almost all of the convergence in Black-white welfare over the past century came from the rapid but incomplete convergence in Black and white mortality rates between 1900 and 1920 birth cohorts. Black-white welfare gaps have declined only slightly since the 1920 birth cohort.

Table 1: Average Earnings at Age 30

Year	White Earnings			Black Earnings			White/Black Earnings		
	Labor	Post-tax	Total	Labor	Post-tax	Total	Labor	Post-tax	Total
1930	16,033	15,786	23,765	7,701	7,664	11,753	2.08	2.06	2.02
1940	16,019	15,805	23,169	6,611	6,588	10,688	2.42	2.40	2.17
1950	23,862	20,465	29,471	13,430	12,009	15,295	1.78	1.70	1.93
1960	36,993	30,471	42,820	20,916	18,088	22,732	1.77	1.68	1.88
1970	52,122	42,127	57,423	33,883	28,577	35,481	1.54	1.47	1.62
1980	46,917	38,443	52,454	31,770	27,045	34,241	1.48	1.42	1.53
1990	45,179	37,418	49,895	26,154	22,311	27,737	1.73	1.68	1.80
2000	47,061	38,613	51,566	29,963	25,242	32,172	1.57	1.53	1.60
2010	38,740	32,687	42,294	21,751	18,868	24,163	1.78	1.73	1.75
2020	38,535	32,463	41,337	24,061	20,689	25,418	1.60	1.57	1.63

Note: Earnings data from default IPUMS census and ACS microdata samples. Units are dollars. Labor earnings are only available in the Census data from 1940-2014 and total earnings only available from 1950-2014. We do not use ACS data from 2015-2016 because the race variable is not easily comparable to 1900-2014 census and ACS data. Data subset to American-born Black and white men who report being age 30 in the census and ACS. Each cell is the average earnings across all living white or Black 30-year old men, including men who earn zero dollars. Labor earnings rely on the INCWAGE IPUMS variable, Total earnings rely on the INCTOT IPUMS variable. Post-tax earnings apply federal income tax rates to the INCWAGE variable. Earnings values in 2020 are equal to 2014 earnings values. 1930 labor and total income values and 1940 total income values are imputed as we describe in the text of the paper. For example, we regress 1940 labor earnings at the individual level on indicators for race, age, occupation, industry, state of birth, and state of residence. We then use these regression coefficients to predict labor earnings for each male in 1930.

Table 2: Lifetime Earnings (undiscounted)

	White males							Black males					
	Labor		Post-Tax		Total			Labor		Post-Tax		Total	
Birth Cohort	Earnings	No Death	Earnings	No Death	Earnings	No Death	+VSL Gap	Earnings	No Death	Earnings	No Death	Earnings	No Death
1900	669	1,067	595	936	1,099	2,077	124	197	523	182	475	302	959
1905	779	1,199	673	1,025	1,257	2,301	184	251	608	226	541	365	1,066
1910	921	1,354	774	1,130	1,473	2,590	179	340	721	299	630	477	1,240
1915	1,118	1,543	919	1,262	1,771	2,914	229	481	862	417	743	656	1,460
1920	1,349	1,762	1,089	1,418	2,101	3,219	158	639	1,006	548	859	856	1,664
1925	1,574	1,977	1,258	1,578	2,406	3,489	297	777	1,154	661	979	1,038	1,885
1930	1,785	2,175	1,423	1,732	2,681	3,725	291	911	1,290	770	1,088	1,223	2,104
1935	1,976	2,351	1,573	1,871	2,929	3,943	252	1,034	1,424	868	1,194	1,396	2,314
1940	2,141	2,502	1,705	1,992	3,157	4,161	298	1,135	1,524	948	1,271	1,539	2,472
1945	2,239	2,584	1,789	2,064	3,307	4,307	244	1,193	1,552	995	1,293	1,643	2,561
1950	2,237	2,563	1,800	2,060	3,330	4,333	217	1,187	1,507	993	1,260	1,678	2,574
1955	2,248	2,571	1,818	2,078	3,369	4,408	177	1,143	1,432	962	1,204	1,667	2,551
1960	2,294	2,615	1,859	2,117	3,461	4,538	190	1,136	1,404	958	1,183	1,702	2,590
1965	2,371	2,688	1,922	2,177	3,606	4,724	199	1,191	1,450	1,004	1,221	1,808	2,718
1970	2,487	2,807	2,016	2,273	3,801	4,971	261	1,256	1,512	1,058	1,273	1,933	2,878

Note: Earnings data from default IPUMS census and ACS microdata samples. Units are thousands of dollars. Labor earnings are only available in the Census data from 1940-2014 and total earnings only available from 1950-2014. We do not use ACS data from 2015-2016 because the race variable is not easily comparable to 1900-2014 census and ACS data. Data subset to American-born Black and white men who report being age 30 in the census and ACS. Each cell represents the average lifetime earnings for white and Black males born in the given birth cohort. Earnings are calculated by summing average earnings for each birth cohort and race across all ages, weighted by the age-specific CDC mortality rate, and assuming that all men live only until age 89. Labor earnings rely on the INCWAGE IPUMS variable, Total earnings rely on the INCTOT IPUMS variable. Post-tax earnings apply federal income tax rates to the INCWAGE variable. Earnings values after 2014 are equal to 2014 earnings values, assuming an additional 1.5% annual growth rate. 1910, 1920, and 1930 labor and total income values and 1940 total income values are imputed as we describe in the text of the paper. For example, we regress 1940 labor earnings at the individual level on indicators for race, age, occupation, industry, state of birth, and state of residence. We then use these regression coefficients to predict labor earnings for each male in 1930. In non-surveyed years from 1916-2014, earnings are linearly interpolated at the age*race*birth year level before being summed to construct lifetime earnings measures. Pre-1940 earnings are adjusted to account for annual variation in wages. This has no effect on our results. The ‘No Death’ columns assume that all newborns live until age 89. The ‘+VSL Gap’ column estimates the value of the Black-white gap, calculated as described in the text.

Table 3: Lifetime Earnings ($\beta = 0.96$)

Birth Cohort	White males							Black males					
	Labor		Post-Tax		Total			Labor		Post-Tax		Total	
	Earnings	No Death	Earnings	No Death	Earnings	No Death	+VSL Gap	Earnings	No Death	Earnings	No Death	Earnings	No Death
1900	122	177	114	163	183	279	130	34	79	33	74	52	123
1905	136	193	124	174	200	299	186	42	89	39	82	59	132
1910	156	214	137	187	225	325	175	55	105	50	94	74	149
1915	187	244	159	206	264	362	221	80	130	71	114	101	175
1920	229	284	189	234	313	409	154	112	161	98	140	134	207
1925	276	332	225	270	364	458	301	143	195	123	167	168	246
1930	324	379	262	306	414	504	304	173	227	148	194	204	284
1935	367	420	295	337	459	546	269	201	257	170	217	235	319
1940	402	453	323	363	497	581	322	226	283	190	238	263	348
1945	420	467	339	376	518	598	264	243	296	204	248	283	364
1950	418	461	340	374	517	592	234	242	288	204	242	284	359
1955	416	457	341	374	514	588	189	229	270	195	229	273	342
1960	419	458	344	376	516	590	199	223	259	190	220	268	333
1965	422	459	346	376	521	593	204	227	261	193	221	276	339
1970	432	468	354	383	533	605	261	235	267	199	226	288	351

Note: See note to Table 2. The only difference here is that the discount rate is set to $\beta = 0.96$.

Table 4: White/Black Lifetime Earnings (undiscounted)

	Labor				Post-Tax				Total			
Birth Cohort	Earnings	No Death	+VSL Gap	Cnsm.	Earnings	No Death	+VSL Gap	Cnsm.	Earnings	No Death	+VSL Gap	Cnsm.
1900	3.40	2.04	4.03	2.30	3.27	1.97	3.96	2.23	3.64	2.17	4.05	2.38
1905	3.10	1.97	3.83	2.20	2.98	1.90	3.79	2.14	3.44	2.16	3.94	2.37
1910	2.71	1.88	3.24	2.05	2.59	1.80	3.19	1.98	3.08	2.09	3.46	2.27
1915	2.32	1.79	2.80	1.88	2.20	1.70	2.75	1.79	2.70	2.00	3.05	2.14
1920	2.11	1.75	2.36	1.76	1.99	1.65	2.27	1.66	2.45	1.93	2.64	2.02
1925	2.03	1.71	2.41	1.69	1.90	1.61	2.35	1.59	2.32	1.85	2.60	1.91
1930	1.96	1.69	2.28	1.64	1.85	1.59	2.22	1.55	2.19	1.77	2.43	1.81
1935	1.91	1.65	2.15	1.60	1.81	1.57	2.10	1.52	2.10	1.70	2.28	1.74
1940	1.89	1.64	2.15	1.58	1.80	1.57	2.11	1.50	2.05	1.68	2.24	1.69
1945	1.88	1.67	2.08	1.57	1.80	1.60	2.04	1.51	2.01	1.68	2.16	1.67
1950	1.89	1.70	2.07	1.60	1.81	1.64	2.03	1.54	1.99	1.68	2.11	1.68
1955	1.97	1.80	2.12	1.69	1.89	1.73	2.07	1.63	2.02	1.73	2.13	1.75
1960	2.02	1.86	2.19	1.76	1.94	1.79	2.14	1.70	2.03	1.75	2.14	1.80
1965	1.99	1.85	2.16	1.75	1.91	1.78	2.11	1.69	1.99	1.74	2.10	1.77
1970	1.98	1.86	2.19	1.74	1.91	1.79	2.15	1.68	1.97	1.73	2.10	1.75

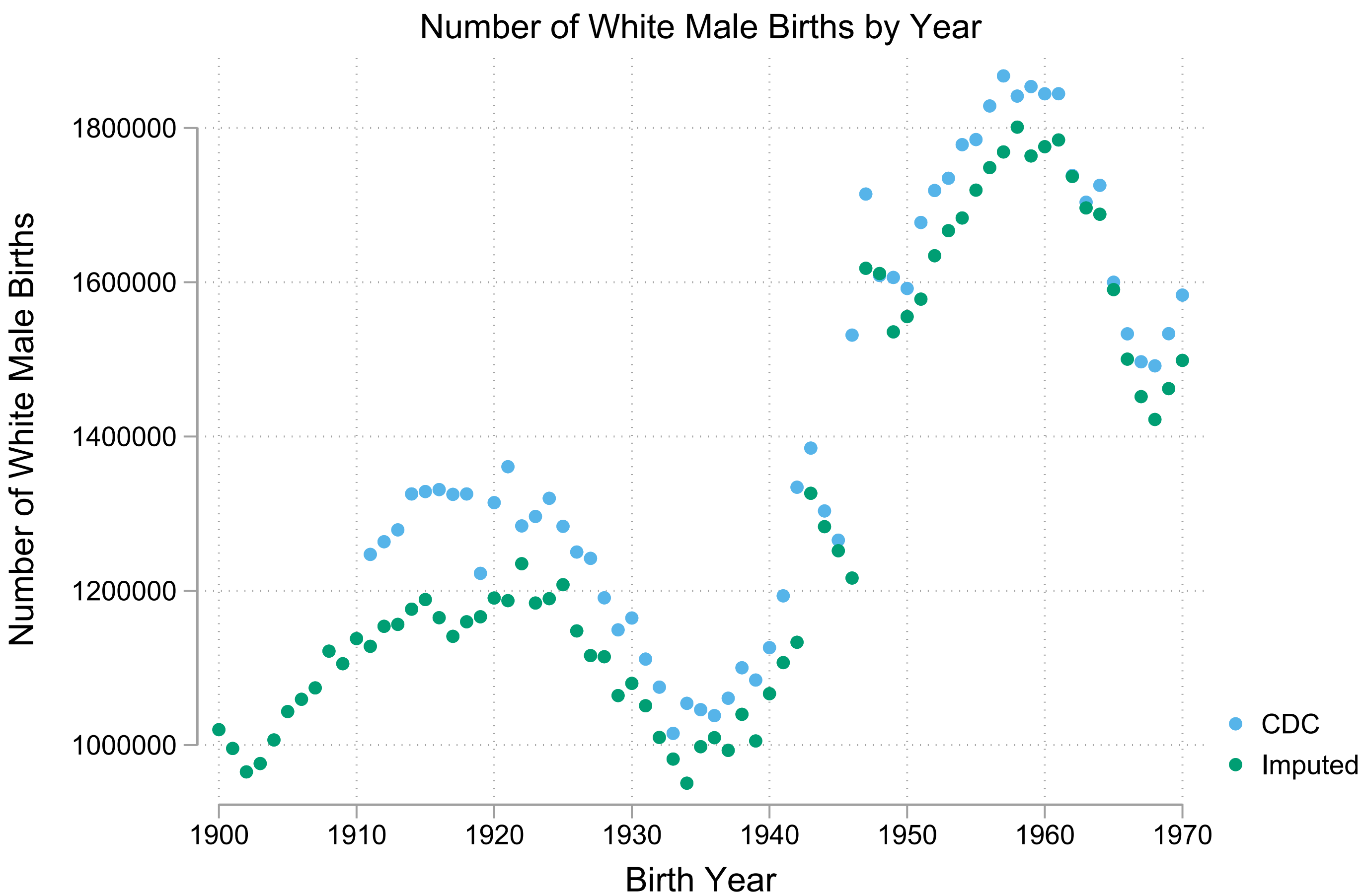
Note: See note to Table 2. This is the ratio of white to Black lifetime undiscounted earnings.

Table 5: White/Black Lifetime Earnings ($\beta = 0.96$)

Birth Cohort	Labor				Post-Tax				Total			
	Earnings	No Death	+VSL Gap	Cnsm.	Earnings	No Death	+VSL Gap	Cnsm.	Earnings	No Death	+VSL Gap	Cnsm.
1900	3.54	2.24	7.31	2.57	3.46	2.20	7.41	2.50	3.55	2.27	6.07	2.66
1905	3.27	2.17	7.73	2.44	3.20	2.13	7.98	2.36	3.39	2.27	6.54	2.62
1910	2.83	2.04	6.01	2.25	2.75	1.99	6.26	2.16	3.04	2.19	5.41	2.48
1915	2.33	1.88	5.09	2.05	2.24	1.80	5.34	1.95	2.62	2.07	4.81	2.33
1920	2.04	1.76	3.42	1.92	1.94	1.67	3.51	1.81	2.33	1.97	3.47	2.20
1925	1.94	1.71	4.05	1.84	1.83	1.61	4.28	1.73	2.16	1.87	3.95	2.07
1930	1.87	1.67	3.63	1.78	1.77	1.58	3.82	1.68	2.03	1.78	3.53	1.96
1935	1.83	1.63	3.16	1.74	1.73	1.55	3.31	1.65	1.95	1.71	3.10	1.88
1940	1.78	1.60	3.21	1.70	1.70	1.53	3.40	1.62	1.89	1.67	3.12	1.83
1945	1.73	1.58	2.82	1.69	1.66	1.52	2.95	1.62	1.83	1.64	2.76	1.80
1950	1.73	1.60	2.70	1.71	1.67	1.54	2.81	1.64	1.82	1.65	2.64	1.79
1955	1.81	1.70	2.64	1.79	1.75	1.64	2.72	1.72	1.88	1.72	2.57	1.85
1960	1.88	1.77	2.77	1.85	1.81	1.71	2.86	1.78	1.92	1.77	2.67	1.89
1965	1.86	1.76	2.76	1.83	1.79	1.70	2.85	1.76	1.89	1.75	2.63	1.85
1970	1.84	1.75	2.95	1.81	1.78	1.69	3.09	1.75	1.85	1.73	2.76	1.82

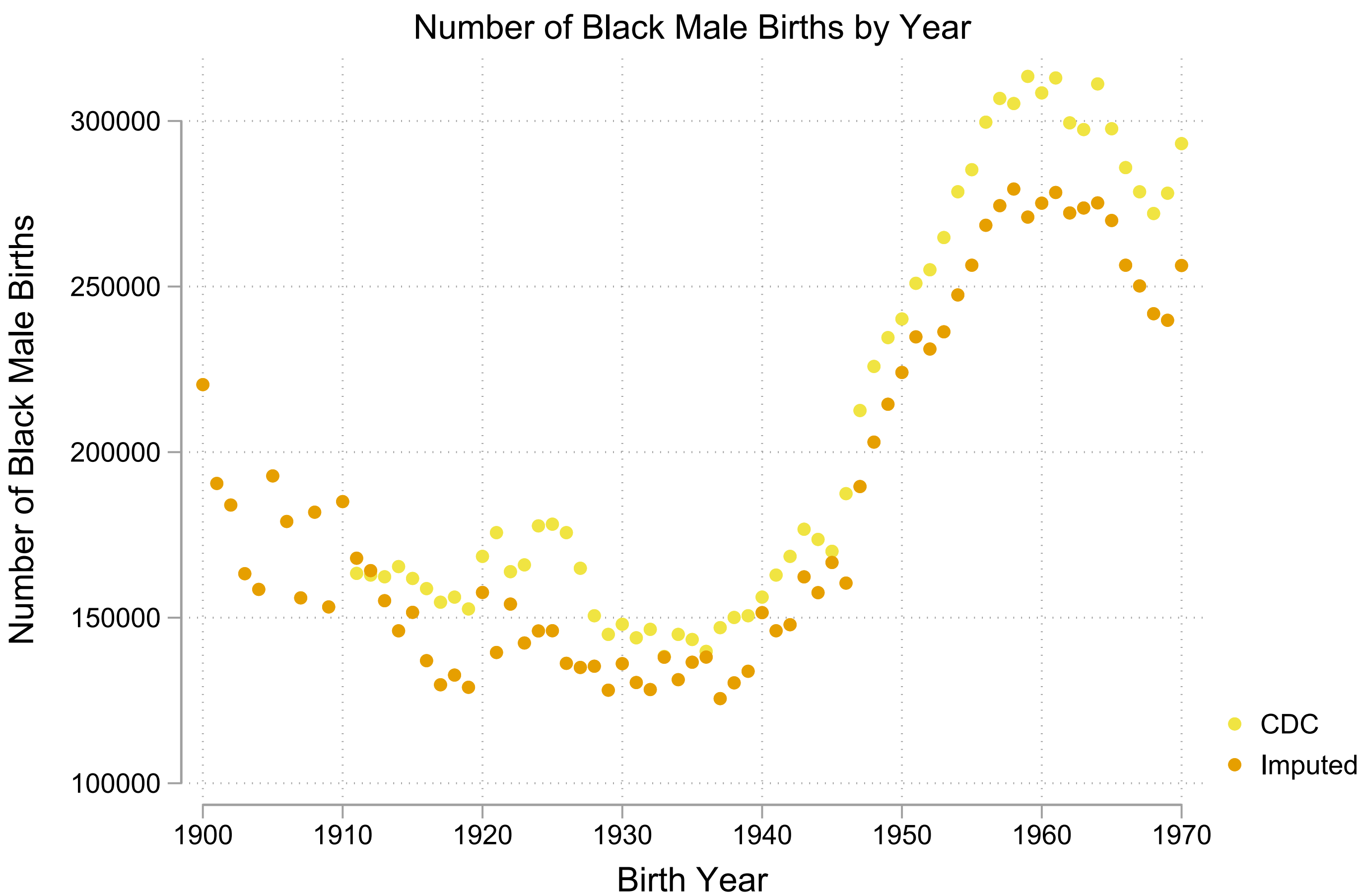
Note: See note to Table 2. This is the ratio of white to Black lifetime earnings with annual discount rate $\beta = 0.96$.

Figure 1:



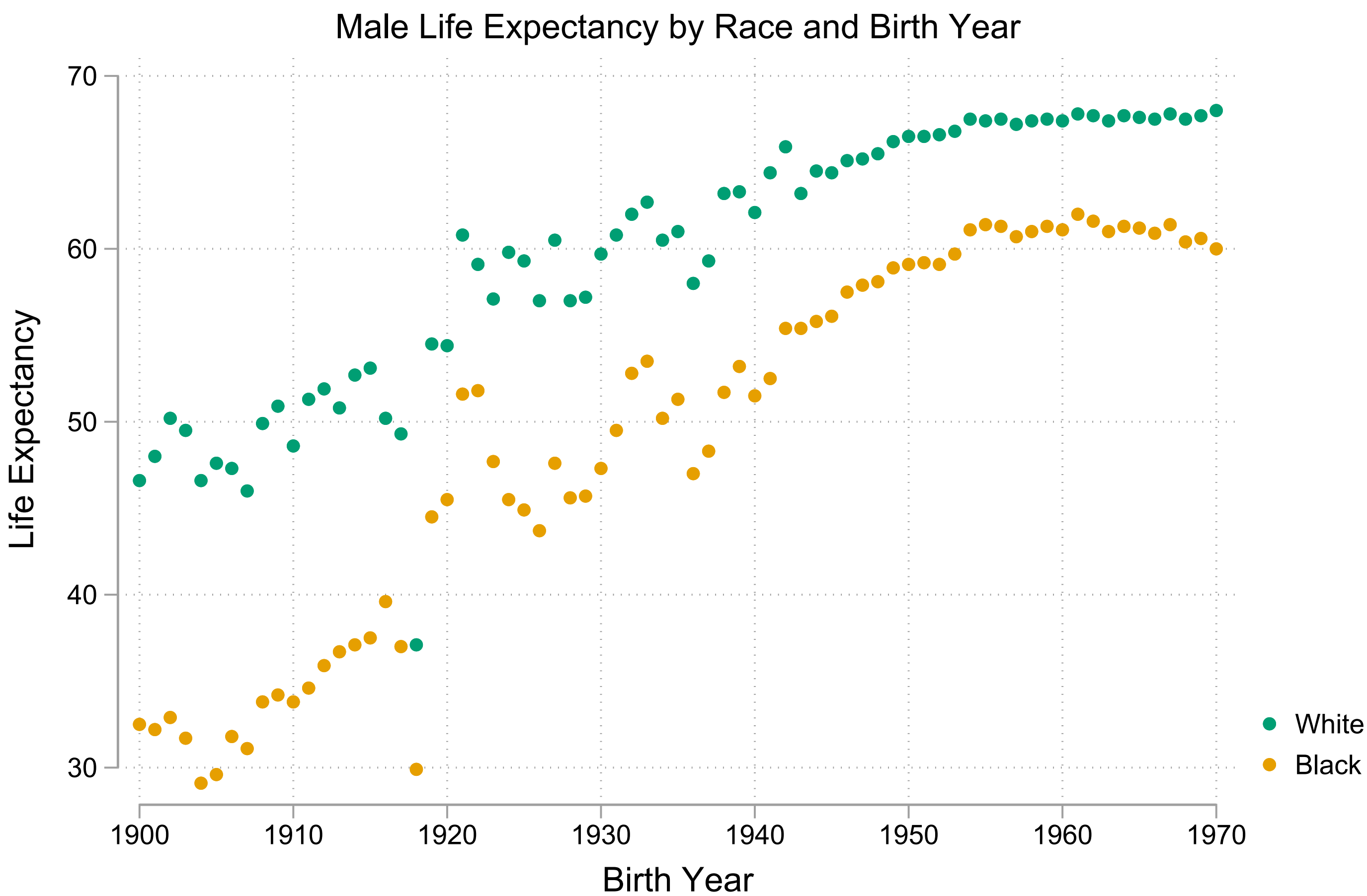
Note: CDC birthcounts based on published CDC data which relies in birth certificates. Imputed birthcounts apply age-specific mortality rates to census birthcounts. The imputed data point for each birth year equals the median imputed birthcount from age 5-60 census age groups.

Figure 2:



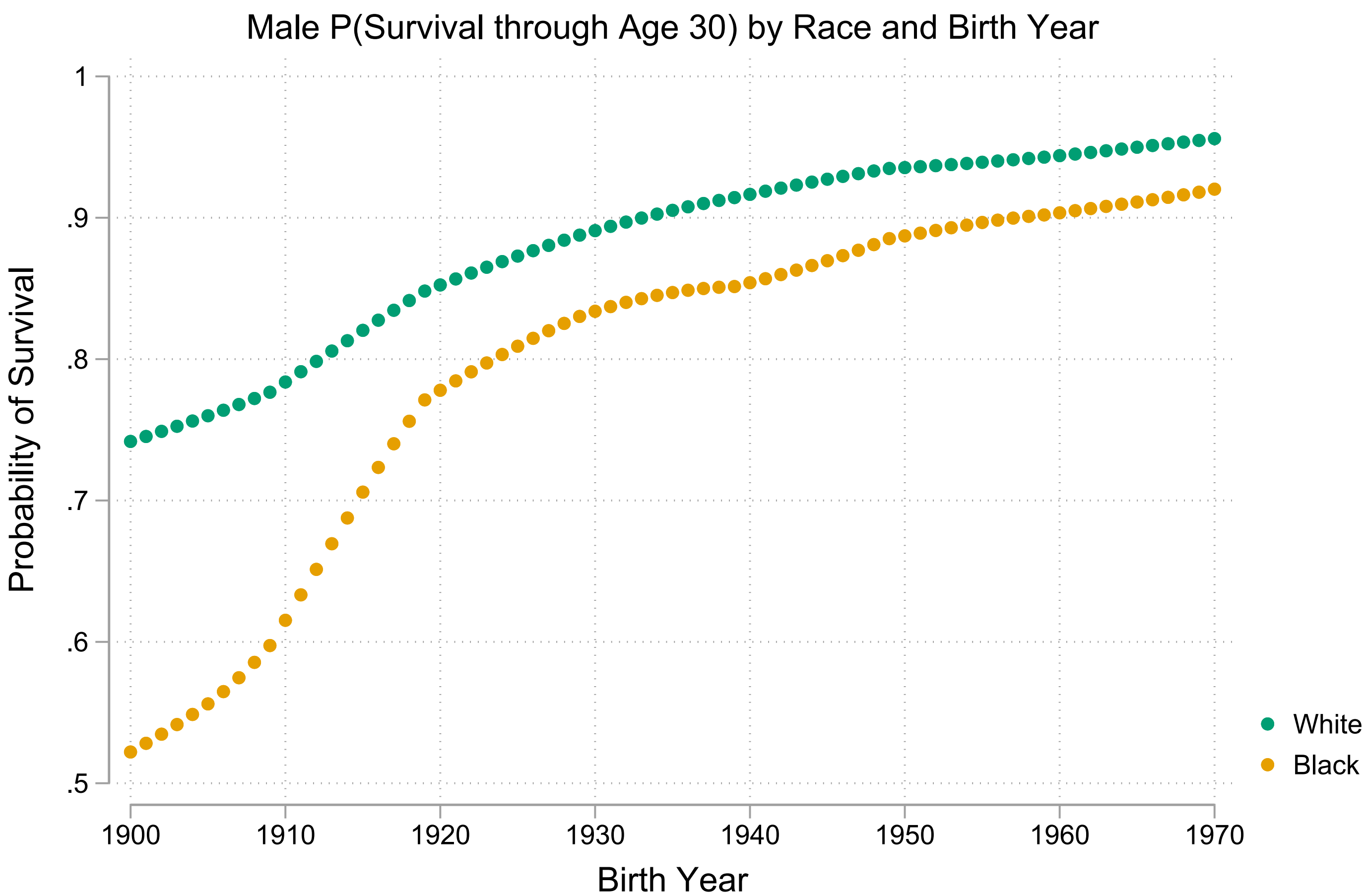
Note: See note to Figure 1.

Figure 3:



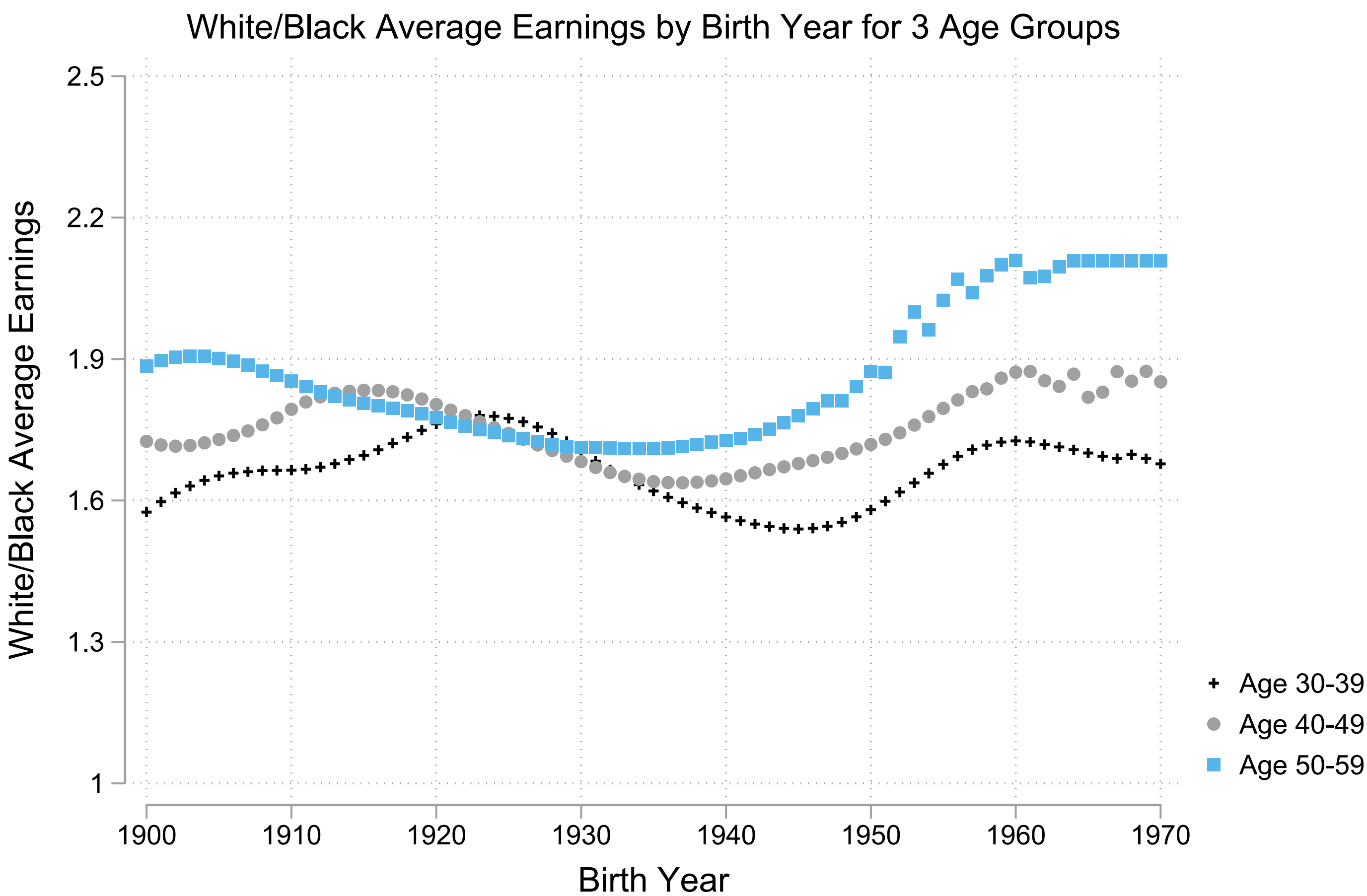
Note: Life expectancy by race taken directly from the CDC (Arias 2011). The life expectancy measures are calculated using that year's mortality rates for each cohort. So the Spanish Flu, which caused large drops in life expectancy for all ages in 1918, had a noticeable effect on life expectancy of Black and white males in 1918.

Figure 4:



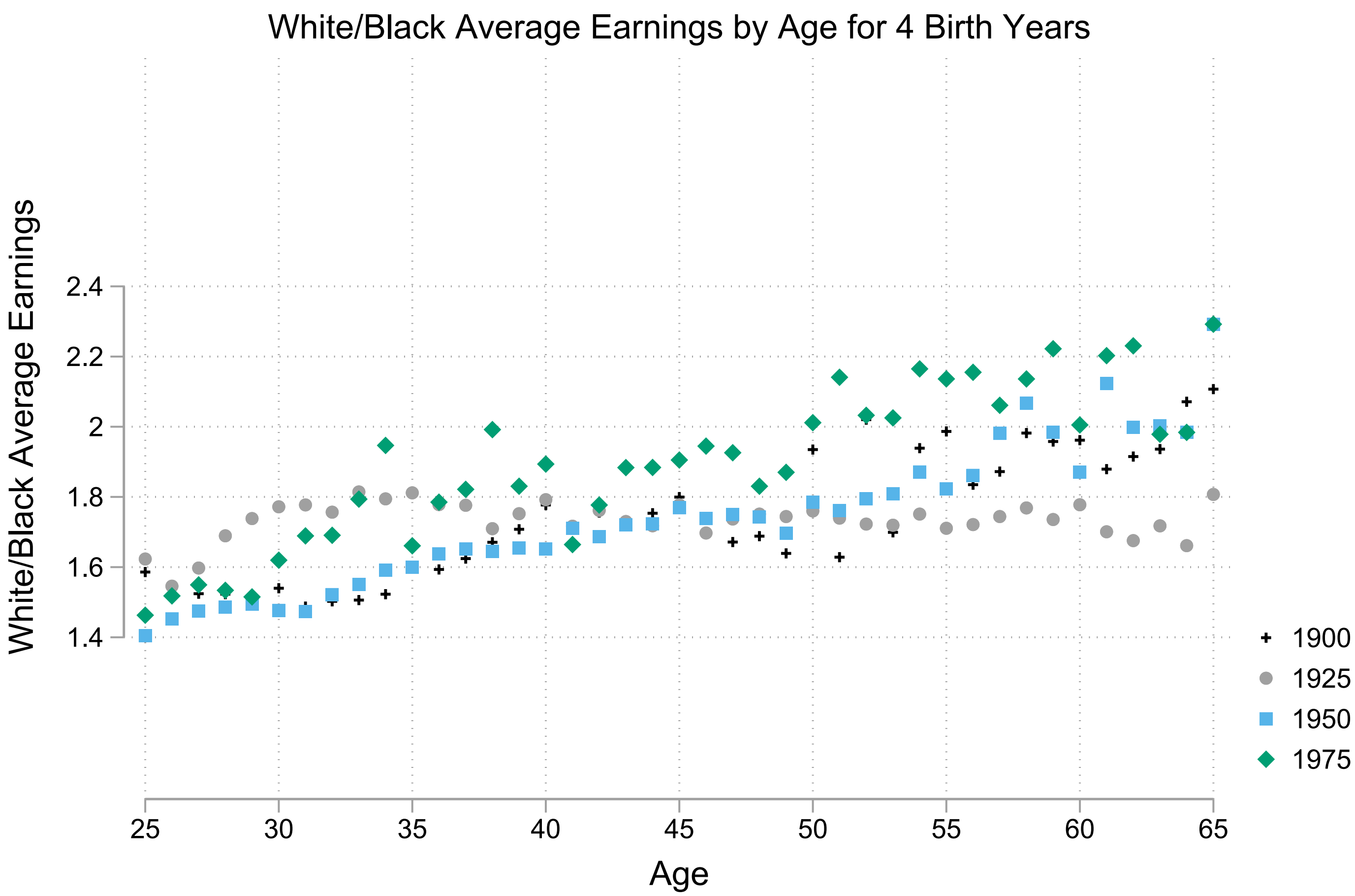
Note: Survivorshop rate taken directly from the CDC (Arias 2011).

Figure 5:



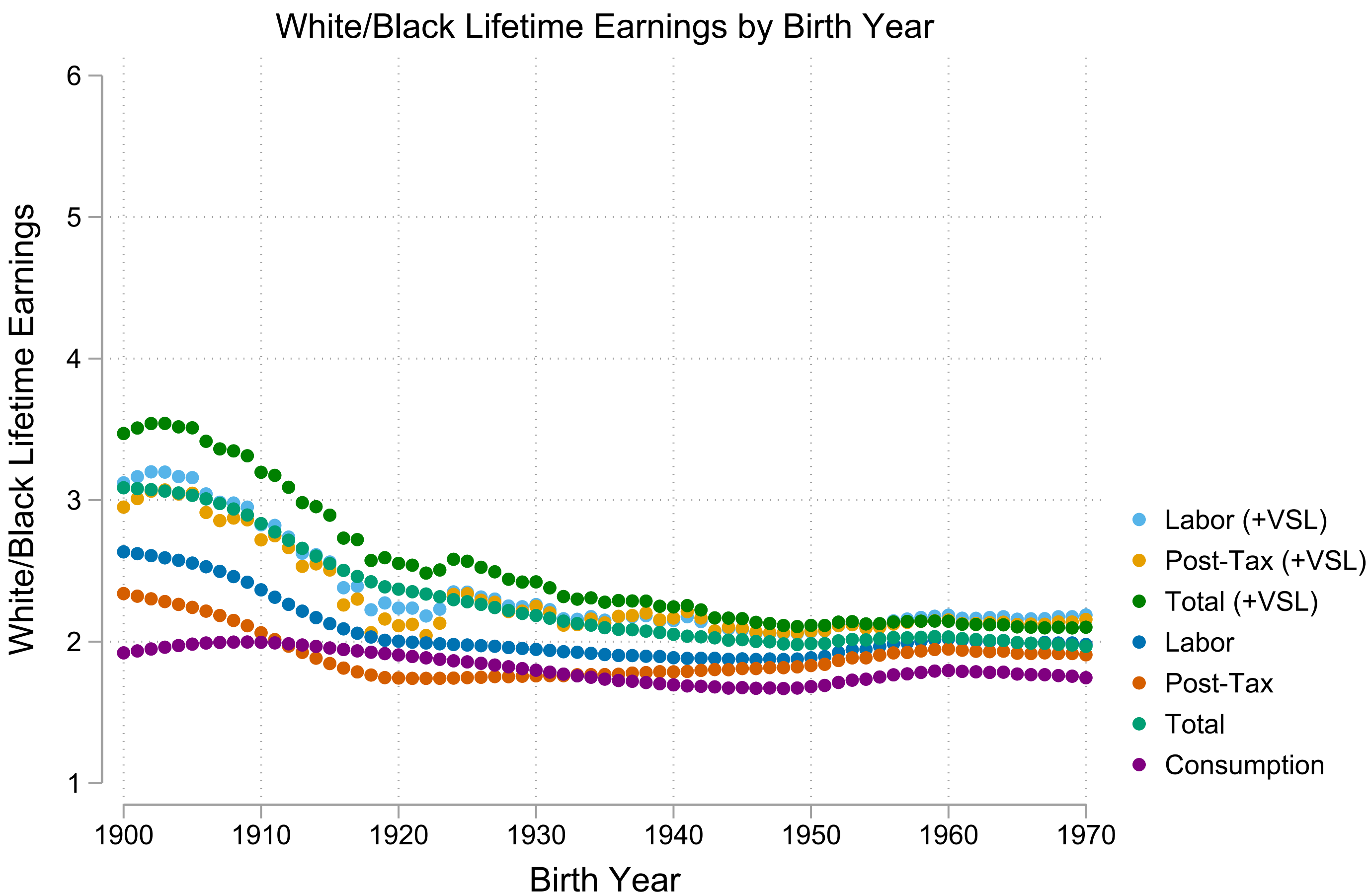
Note: See note to Table 2. Earnings are linearly interpolated by race*age*birth year cell in non-census years and then averaged within 10-year age bins for each birth cohort to produce these scatter plots at an annual level. We assume that earnings after 2014 are equal to earnings in 2014 (within race*age cells). This is only relevant for the oldest age group in this figure.

Figure 6:



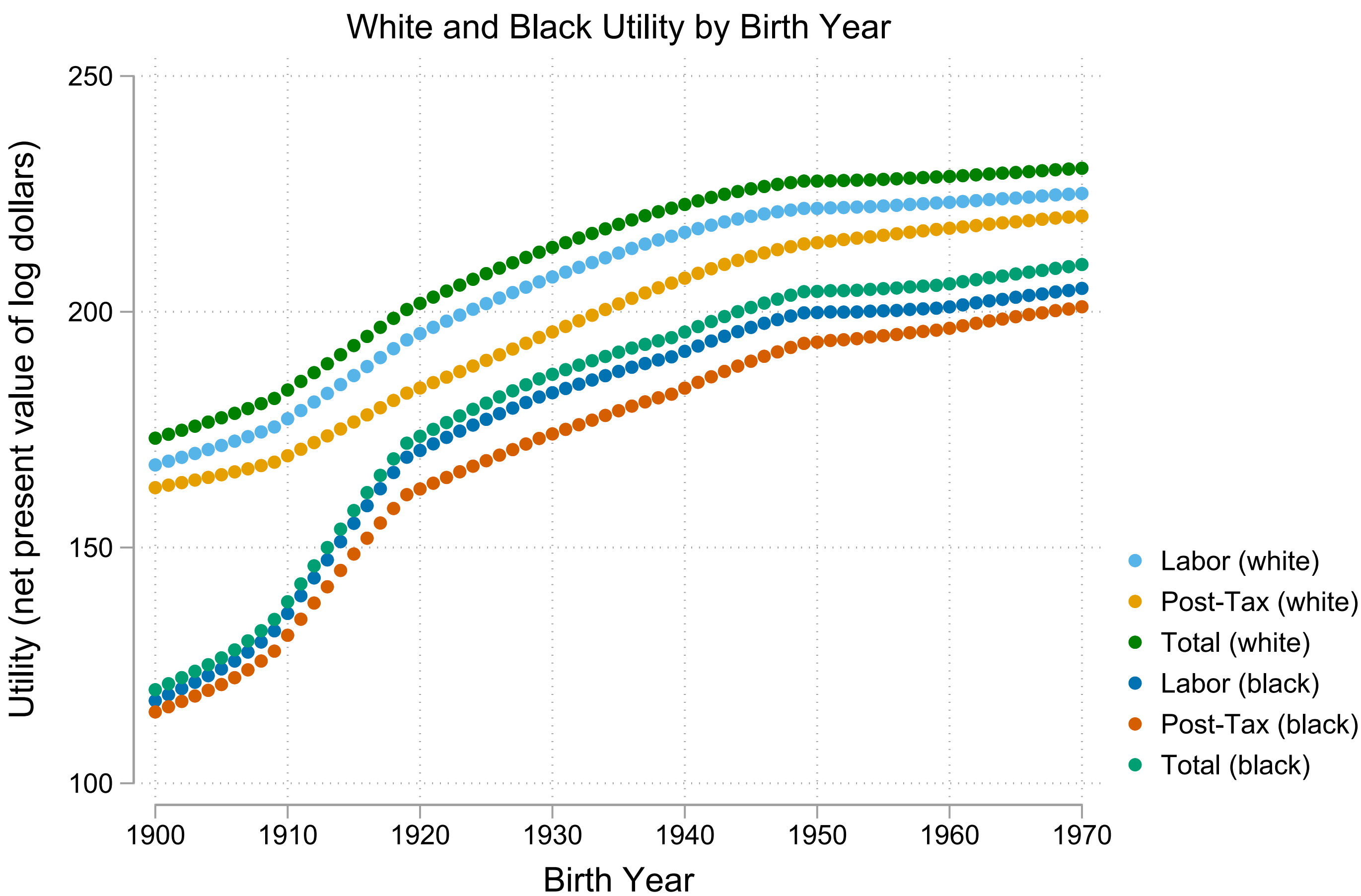
Note: See note to Figure 5.

Figure 7:



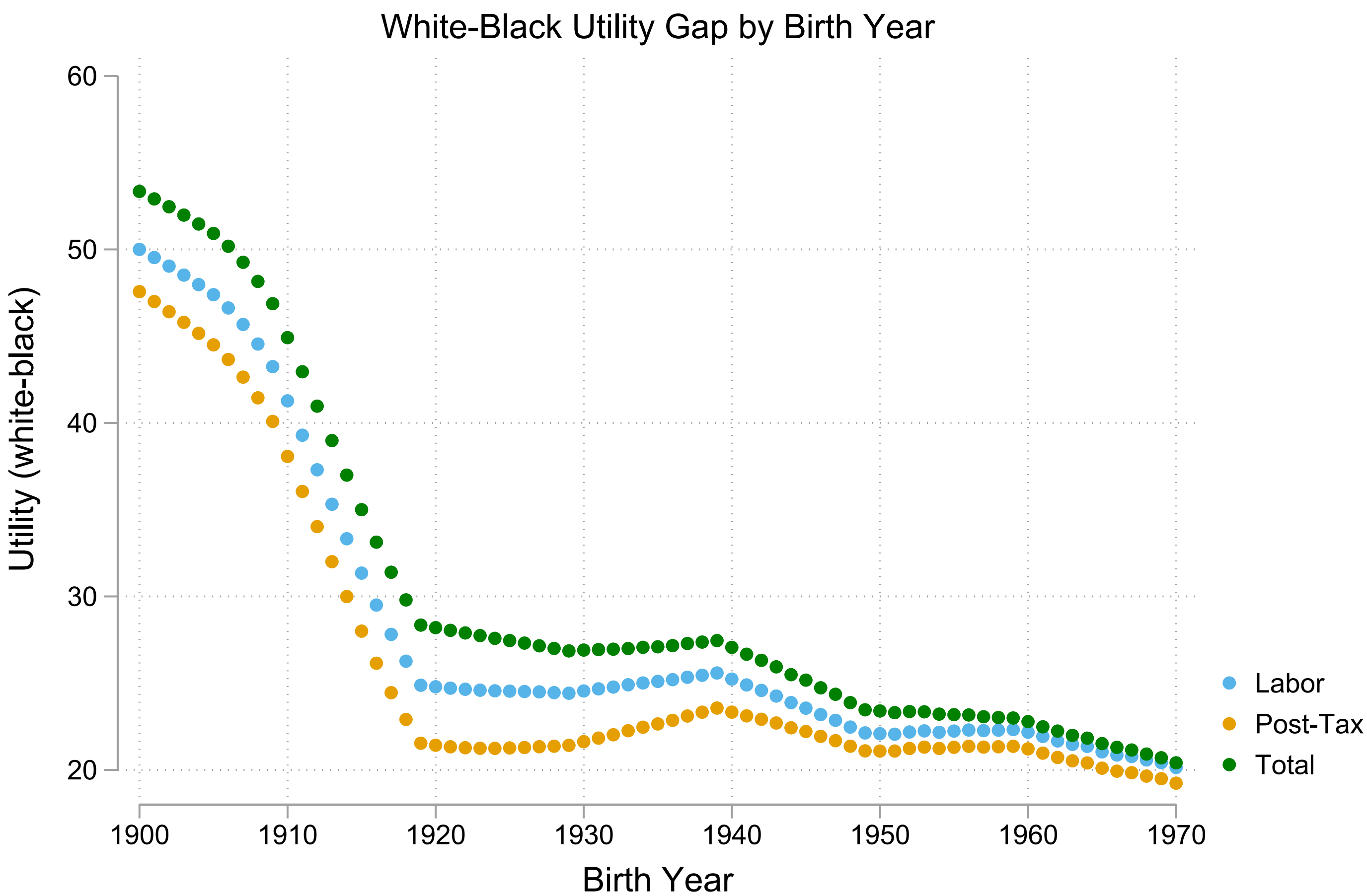
Note: See note to Table 2. This is the ratio of undiscounted lifetime earnings. The +VSL lines correspond to the thought experiment we describe in the text, where we take the ratio of undiscounted white lifetime earnings + the value of the additional life-years each white male can expect to receive to undiscountd Black lifetime earnings. The consumption line corresponds to the lifetime expected consumption of white males divided by the lifetime expected consumption of Black males born in each birth cohort. Here, consumption is calculated assuming $\beta = 1$, but this ratio is quite similar when the consumption line is calculated using $\beta = 0.96$.

Figure 8:



Note: Each line is the level of utility for white or Black males, extracted from the structural model we calibrate in the paper. We assume a discount rate of $\beta = 0.96$

Figure 9:



Note: See note to Figure 8. This is simply the level difference in white and Black utility from Figure 8. We include it to emphasize the large convergence in white and Black utility between the 1900 and 1920 birth cohorts, followed by general stagnation.

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