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BLACK AND WHITE FERTILITY, DIFFERENTIAL BABY BOOMS: THE VALUE OF EQUAL EDUCATION OPPORTUNITY

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Abstract: This paper produces new estimates for white and black mortality and fertility at the state level from 1800(20)–2000. It produces new estimates of black and white schooling for this same period. Using a calibrated model of black and white parents, we fit the time series of black and white fertility and schooling. We then produce estimates of the benefits of equal education opportunity for blacks over the period 1820–2000. For the better part of US history, blacks have suffered from less access to schooling for their children than whites. This paper quantifies the magnitude of this discrimination. Our estimates of the welfare cost of this discrimination prior to the Civil War range between 0.5 and 20 times black wealth, and between 0.5 and 10 times black wealth prior to 1960. Further we find that the Civil Rights era was valued by blacks in the South by between 1% to 2% of wealth. Outside of the South, we find significant costs of discrimination prior to 1960, ranging from 6% to 150% of black wealth. For these divisions from 1960–2000, blacks have attained rough parity in schooling access. The welfare magnitudes are similar to the hypothetical gains to blacks if they had white mortality rates. We show that the model's black and white human capital series are strongly, positively correlated with state output measures, black and white permanent incomes and black and white earnings.

For more than two centuries, African Americans faced extraordinary levels of discrimination compared with whites. Each of the seven children born into a typical African American household in 1860 could expect to acquire less than a single year of formal schooling, compared with 4.5 years for each of the five children born into a typical white household. By the year 2000, black fertility had declined to 2.2 and formal schooling had risen to 14.3 years, not much different than the figures of 2.0 and 14.9 for whites.

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Our paper presents newly compiled data on state black fertility, 1820–2000, and white fertility, 1800–2000. This data was produced using US Census surveys for children ever born covering years 1890–1990. For 2000, we used the 1998, 2000, 2002, and 2004 CPS Supplements surveys of children ever born. For years prior to 1890, we used the age structure of the population, and estimates of infant and young child mortality to produce new estimates of fertility by race and state. For schooling, we followed our procedure in Murphy, Simon and Tamura (2008) to construct expected years of schooling for cohorts by state and by race. See below for more details, as well as the appendix.

This paper documents and attempts to place a value on the improvement in black schooling and mortality between 1820 and 2000 by parameterizing a dynamic, dynastic model of fertility choice with both quantity and quality dimensions (Becker, Murphy and Tamura 1990; Murphy, Simon and Tamura 2008). In this model, parents choose gross fertility and the level of human capital with which to invest each child, conditional on the probability of the child surviving to adulthood, schooling cost, and the productivity of human capital investment.[1]

A parameterized, dynamic, dynastic fertility model is a promising framework for valuing the gradual lifting of discriminatory barriers against blacks. For example, discriminatory access to health care would increase child mortality and thus increase the precautionary demand for children (Kalemli-Ozcan 2002, 2003; Tamura 2006). Prior to 1870, one out every two black child ever born did not survive to young adulthood, compared with one in three among whites. After 1960, 95 black children and 98 white children in 100 survive. Because fertility is costly, this reduces the resources available for schooling the next generation.

One manifestation of racial discrimination against blacks was unequal access to schooling (Margo 1990; Canaday and Tamura 2009, Carruthers and Wanamaker (2015)). In this model, human capital accumulates from one generation to the next, and is used, along with parental time, to produce the next generation's human capital. The effects of such discrimination are therefore manifested in two ways. First, because human capital is transmitted from one generation to the next, discriminatory access to schooling in one generation means that the next generation must start with a lower level of human capital than otherwise. Second, because parents' human capital is used to produce the next generation's human capital, dynasties with lower parental human capital are less efficient in producing child human capital.

We parameterize the fertility model by fitting decadal US time series on fertility, mortality, and schooling for blacks and whites, by state, for the time period 1800–2000. Our parameterization eschews the use of data on income, which are not available until 1940, for two reasons. First, much of our interest lies in the earlier years. Second, the fact that inequality is transmitted from one generation to the next complicates measurements of discrimination based on current labor market earnings. Part of the value of human capital lies in its productivity in producing and educating one's children.

The quantity–quality fertility model permits us, in absence of data on income, to calculate the reduction of black welfare due to higher mortality and schooling cost, in units of human capital. Because wealth is proportional to human capital, the ratio of white to black human capital is a natural metric for welfare. It is therefore possible to calculate the proportionate increase in wealth that would have been required to compensate blacks for the higher mortality and schooling costs they faced, compared with whites. To foreshadow our findings, the estimates indicate that prior to 1960, black wealth would have had to increase by between 60% and 500%.

We do not intend our measurements to fully capture the burden of racial discrimination, which impacted a greater range of economic activity than schooling alone, and which included social costs above purely economic costs. That being said, we think that our paper represents a step forward in measuring the costs of discrimination by explicitly considering its implications for a largely non-market, yet fundamental activity, namely that of raising and schooling one's children.

The remainder of the paper is organized as follows. Section 1 presents our data. Section 2 outlines our theoretical model. The numerical solutions to the model are presented in Section 3. Section 4 presents a robustness check on the parameterization. Section 5 examines the plausibility of our estimates of human capital. Section 6 concludes with a brief summary and an outline of future paths of research.

1. DATA

In this section, we present new data on the price of space, fertility, schooling, and mortality risk, by race.

1.1. Price of Living Space

We use a variant of the model from Tamura and Simon (2015), and Murphy, Simon and Tamura (2008) to calibrate for white and black fertility in each state. In those papers, the forcing variable that induces the Baby Boom is a reduction in the price of space.[2] For this paper, we computed race specific, state specific "price" of space measures, taken to be equal to population density. For each state, race, and year we compute the state population density. We compute the population density of each county, and then weight each county by the county's share of the white or black state population. Consider state i, with $J > 1$ counties. Let $size_{ijt}$ represent the number of square miles county j in state i in year t has. Then, the population density of state i for race $R =$ black (b), white (w) is given as

$$r_{iRt} = \sum_{j=1}^{J} \frac{pop_{ijt}}{size_{ijt}} \frac{pop_{ijt}^{R}}{pop_{it}^{R}}. \quad (1)$$

Thus for each year, each state, for blacks (whites), we have the number of people per square mile for a randomly chosen black (white) in the state. It is quite possible

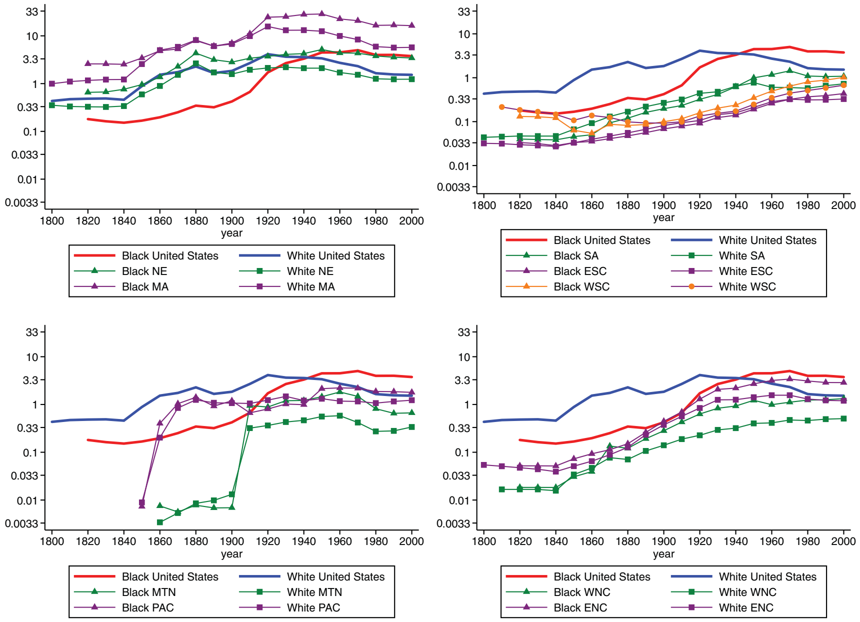

FIGURE 1. (Colour online) Black and white price of space, $r_t^{b,w}$ in 1000s per square mile.

that population density can decline even when the state population rises. This occurs when the population share of the lower density counties rises sufficiently, more than offsetting the rise in population density of any or even all counties. Additionally, the US population density can decline even though the US population has never declined, as population within a state becomes less dense as above, or if population shares of less densely populated states (typically the south and west) rise. These are graphed in Figure 1, nationally and by division. Nationally, white population density rises from 1800 until 1920 and then declines for the remainder of the years. From 1800 to 1940 whites lived in more densely populated areas than blacks. For the period which covers the Baby Boom years, 1950–1970, and the Baby Bust years, 1980–2000, blacks have a higher population density than whites. For blacks, generally their price of space rises from 1820 to 1970. Indeed the onset of the black Baby Boom appears to be totally driven by the dramatic decline in the cost of schooling, as will be detailed below. Only in the last 30 years has population density for blacks declined.

1.2. Fertility

Our fertility data for years 1890–2000 are derived from information on children ever born to ever married women aged 35–44 years, collected from decennial Censuses. We used the procedures used in Murphy, Simon and Tamura (2008) to

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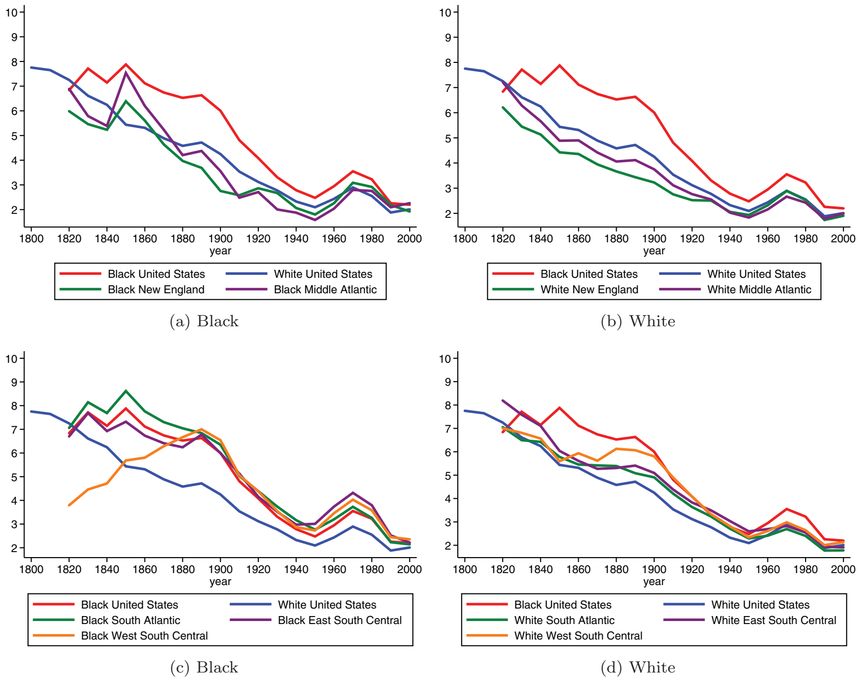

(a) Black (b) White

(c) Black (d) White

FIGURE 2. (Colour online) Cohort black and white fertility.

produce estimates of black and white fertility for years prior to 1890.[3] Figures 2 and 3 graph white and black fertility for the US as a whole between 1800 and 2000 and by census division. White fertility in 1800 was 7.8, and declined to 7.4 in 1820, 6.3 in 1840, and 5.3 in 1850. Black fertility averaged 6.8 in 1820 (the start of the series), rose to 7.7 in 1830, and fell to 7.1 in 1840. Generally, fertility among blacks and whites declined steadily until 1950, to 2.1 for whites and 2.5 for blacks, rose during the baby boom until 1970, and resumed their decline until the end of the data period in 2000. The fertility of blacks exceeded that of whites thereafter, but had converged to within 0.19 by 2000. The black–white fertility differential is largest in 1850, more than 2.5 children ever born (7.9–5.3). By 1950, the gap had shrunk to just 0.4, (2.48–2.09).[4] The information is contained in Table 1.

Table 2 contains information on the size of the Baby Boom by race and by census division. We compare the magnitude to the national Baby Boom both in absolute change and in proportionate change. The 1950 cohort of 35–44 women have the lowest fertility prior to 2000, therefore we benchmark our change in fertility between the 1950 cohort and the 1970 cohort. As we found in our previous work, Murphy, Simon and Tamura (2008), the Baby Boom for white women was larger in the northern divisions compared with the southern divisions. However, the Baby

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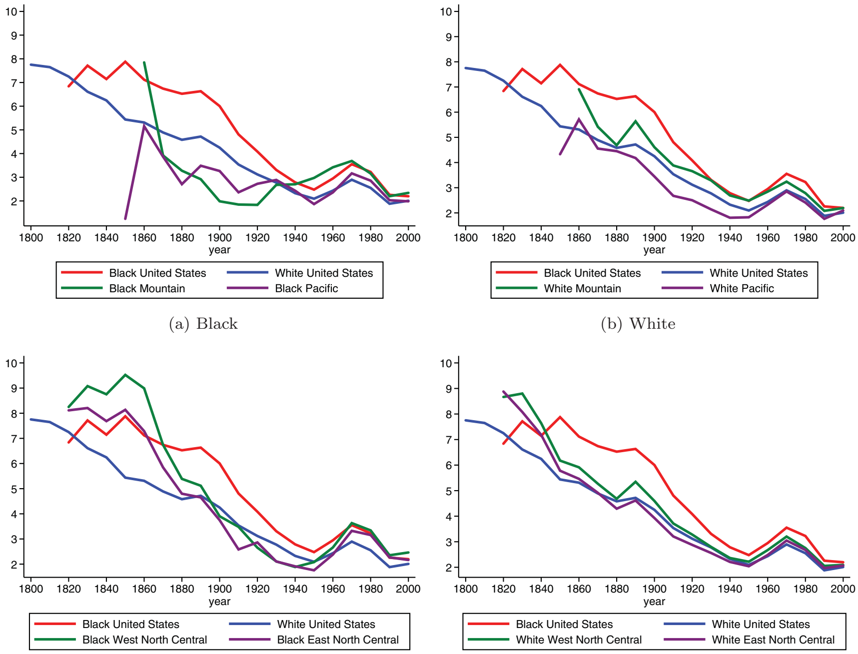

(a) Black (b) White

(c) Black (d) White

FIGURE 3. (Colour online) Cohort black and white fertility.

Boom for black women was generally large everywhere, with the exception of the Mountain division.[5]

Alternative theories of the Baby Boom abound. Easterlin (1961, 1966) provided a model of preference formation that caused Depression children to have low expectations of adult consumption. When the Depression ended and the Post World War II Boom occurred, they consumed some of the unexpected wealth in the form of larger families. These boomer children, accustomed to 1950s and early 1960s abundance, expected high levels of adult consumption. When they became adults in the productivity slow down they reduced their fertility to deal with the unexpected slower growth. Greenwood, Seshadri and Vandenbroucke (2005) argue that labor saving appliances in the household increased the demand for children, but this increased productivity was not continuous, but rather a one time shock to the level of household technology. However, see Bailey and Collins (2011) on the effects of electrification and fertility for some contrary evidence. Doepke, Hazan, Maoz (2015) argue that differential rates of female mobilization during World War II sowed the seeds of the post war Baby Boom. Albanesi (2013) and Albanesi and Olivetti (2014) provide evidence on the effect of declining maternal mortality risk and possible baby boom responses. Jones and Schoonbroodt (2010) relax some assumptions of the Barro–Becker altruism utility function in order to provide the

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TABLE 1. Children ever born: By census division and race

Year	NE	MA	SA	ESC	WSC	MTN	PAC	WNC	ENC	US
					White					
1800	7.57	7.85	7.67	9.19	–	–	–	–	10.5	7.83
1820	6.30	7.27	7.10	8.23	7.08	–	–	8.82	8.88	7.31
1840	5.20	5.71	6.47	7.14	6.64	–	–	7.77	7.19	6.30
1860	4.12	4.93	5.26	5.47	5.77	7.09	5.55	5.77	5.46	5.18
1880	3.42	4.13	5.21	5.17	5.92	4.56	4.32	4.58	4.29	4.47
1900	3.22	3.75	4.91	5.10	5.80	5.30	3.45	4.60	3.93	4.26
1920	2.52	2.76	3.64	3.83	4.09	3.66	2.50	3.28	2.88	3.12
1940	2.06	2.03	2.71	3.04	2.82	2.69	1.81	2.36	2.21	2.33
1950	1.93	1.83	2.29	2.60	2.34	2.49	1.83	2.22	2.04	2.09
1960	2.32	2.16	2.41	2.69	2.61	2.84	2.33	2.67	2.48	2.44
1970	2.89	2.66	2.70	2.82	2.98	3.24	2.85	3.20	3.05	2.90
1980	2.53	2.42	2.40	2.55	2.64	2.78	2.41	2.75	2.68	2.55
1990	1.74	1.79	1.77	1.94	2.01	2.08	1.76	2.06	1.97	1.88
2000	1.90	1.99	1.78	1.91	2.14	2.19	2.09	2.09	2.07	2.01
					Black					
1820	5.99	6.89	7.06	6.70	3.79	–	–	8.25	8.11	6.84
1840	5.75	6.27	7.60	6.81	4.72	–	–	8.62	7.69	7.10
1860	5.61	6.20	7.76	6.73	5.80	7.85	5.16	8.99	7.29	7.12
1880	3.97	4.21	7.04	6.24	6.67	3.28	2.71	5.39	4.80	6.53
1900	2.75	3.56	6.35	5.99	6.54	1.99	3.26	3.90	3.75	6.00
1920	2.86	2.71	4.39	4.15	4.38	1.83	2.72	2.65	2.86	4.08
1940	2.07	1.88	3.17	2.98	2.87	2.70	2.43	1.88	1.91	2.79
1950	1.80	1.58	2.77	3.01	2.73	2.97	1.87	2.08	1.75	2.48
1960	2.26	2.04	3.20	3.74	3.46	3.42	2.36	2.66	2.38	2.95
1970	3.09	2.80	3.73	4.32	4.03	3.69	3.16	3.63	3.32	3.55
1980	2.92	2.76	3.26	3.80	3.58	3.16	2.86	3.34	3.16	3.22
1990	2.19	2.10	2.23	2.52	2.45	2.20	2.03	2.35	2.27	2.26
2000	1.92	2.26	2.14	2.22	2.36	2.34	1.98	2.46	2.16	2.20

Table reports our estimates of children ever born from 1800–1880 for whites and 1820–1880 for blacks using the procedure of Murphy, Simon and Tamura (2008). For 1890–1990, we report the values of children ever born to women 35–44 from various censuses. The 2000 value comes from the averaged children ever born to women 35–44 for 1998, 2000, 2002, 2004 CPS.

possibility of baby booms. However, the results in this paper do not hinge on this particular interpretation; all that is required is a decline in the price of some good that is complementary with fertility.

1.3. Schooling

Estimates of schooling by race and state, obtained by extending the procedures of Turner, Tamura, Mulholland and Baier (2007) and our previous paper (2008) are seen in Table 3 and in Figures 4 and 5, by cohort.[6] Starting in 1839, blacks

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TABLE 2. Changes in children ever born: By census division and race

Division	Absolute change from 1950 to 1970	Relative to national change	Percentage change from 1950	Relative to national percentage change
		White		
NE	0.96	1.19	49.5	1.29
MA	0.83	1.04	45.5	1.19
SA	0.40	0.50	17.5	0.46
ESC	0.23	0.28	8.8	0.23
WSC	0.65	0.81	27.6	0.72
MTN	0.75	0.94	30.2	0.79
PAC	1.02	1.28	56.1	1.47
WNC	0.98	1.23	44.4	1.16
ENC	1.01	1.26	49.3	1.29
US	0.80		38.3	
		Black		
NE	1.29	1.20	71.0	1.65
MA	1.22	1.13	77.1	1.78
SA	0.96	0.90	34.9	0.80
ESC	1.31	1.22	43.5	1.00
WSC	1.30	1.21	47.6	1.10
MTN	0.72	0.67	24.1	0.55
PAC	1.30	1.21	69.5	1.60
WNC	1.55	1.44	74.6	1.72
ENC	1.57	1.46	89.4	2.06
US	1.08		43.4	

Table reports both absolute, proportionate, and relative change in fertility during the Baby Boom, by race. In each relative case, we report the changes in comparison to the national change by race.

obtained an average of just 0.15 years of schooling, compared with 3.4 years among whites, a figure not achieved by blacks until the 1879 cohort. By 2000, both blacks and whites are predicted to have between 14 and 15 years of schooling.

Table 4 contains a breakdown of the change in years of schooling over the Baby Boom. For whites, the increase in schooling of the 1970 Baby Boom, 1959 birth year, compared with the 1950 Baby Bust, 1939 birth year, is 2.6 years. This was almost a 25% increase in years of schooling across cohorts. The largest increase in white years of schooling occurred in the four small Baby Boom divisions. This is true whether we compare the absolute changes in schooling with the national change, or if we compare percentage increase in schooling with the national percentage increase in schooling.

For blacks, national schooling rose over the baby boom by 3.2 years, or more than 33%. The largest increase in schooling years occurred in the three southern divisions, South Atlantic, East South Central, and West South Central. Again this is true whether measure comparing absolute years of schooling increases with

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TABLE 3. Cohort average years of schooling: By census division and race

Year	NE	MA	SA	ESC	WSC	MTN	PAC	WNC	ENC	US
					White					
1850	4.52	4.08	2.04	1.85	1.37	–	0.33	2.16	3.82	3.37
1860	5.07	5.14	3.25	4.20	2.25	2.61	3.83	4.30	5.06	4.59
1870	5.66	5.49	3.53	4.40	3.69	3.08	5.00	5.03	5.53	5.06
1880	7.30	6.32	5.77	5.72	4.50	4.23	5.58	6.24	6.38	6.17
1890	7.82	6.82	6.36	6.36	6.50	5.66	6.03	6.79	6.88	6.76
1900	8.30	7.44	6.83	6.88	6.75	6.86	7.06	7.41	7.49	7.34
1910	8.98	8.26	7.51	7.36	7.52	7.82	8.80	8.35	8.36	8.17
1920	9.53	9.06	8.19	7.97	8.23	8.95	9.98	9.26	9.24	8.98
1930	10.5	10.3	9.46	8.87	9.36	10.5	11.4	10.5	10.5	10.2
1940	11.9	11.7	10.9	9.72	10.6	11.7	12.3	11.1	11.5	11.3
1950	11.7	11.6	11.1	10.3	11.0	11.9	12.5	11.4	11.3	11.4
1960	12.5	12.2	12.2	11.5	11.9	12.6	12.6	12.3	12.0	12.2
1970	14.2	13.9	14.4	13.4	14.2	14.6	14.6	13.9	13.5	14.0
1980	14.5	14.5	14.9	14.1	14.5	15.2	14.8	14.9	14.5	14.6
1990	13.2	13.4	14.1	13.7	13.4	14.6	13.5	14.3	13.9	13.7
2000	14.9	14.9	15.0	14.9	14.7	15.0	14.8	14.9	14.9	14.9
					Black					
1850	1.76	1.39	0.06	0.02	0.31	–	0.00	0.24	1.04	0.15
1860	3.81	2.88	0.26	0.26	0.65	0.00	1.50	1.78	3.32	0.50
1870	4.42	3.48	0.71	0.83	0.72	0.61	3.22	2.25	3.74	0.99
1880	5.01	4.67	2.13	2.48	1.40	0.73	3.44	4.00	4.74	2.33
1890	5.53	5.16	3.28	3.61	2.54	2.93	4.69	5.75	5.39	3.45
1900	6.48	5.99	4.21	4.32	3.80	5.27	5.60	6.30	6.22	4.36
1910	7.60	6.91	5.11	5.04	5.02	6.46	7.66	7.12	7.05	5.29
1920	8.62	8.02	5.76	5.91	5.85	7.82	9.63	8.44	8.13	6.18
1930	9.64	8.94	6.57	6.34	6.74	9.57	10.8	9.65	9.55	7.14
1940	10.5	9.90	7.41	6.79	7.54	10.0	11.7	9.89	10.2	7.92
1950	11.2	10.5	8.60	8.17	8.90	11.0	12.2	10.3	10.4	9.22
1960	11.3	11.3	10.4	10.1	10.5	11.6	12.0	11.0	11.1	10.7
1970	12.9	12.9	12.1	11.6	12.1	13.6	13.6	12.3	12.5	12.4
1980	13.0	12.8	12.9	12.4	12.7	14.2	13.6	13.0	12.9	12.9
1990	12.2	12.2	13.1	12.3	12.6	13.4	12.7	12.9	12.5	12.6
2000	14.3	14.2	14.4	14.3	14.2	14.6	14.2	14.4	14.2	14.3

Table reports our estimates of years of schooling by cohort from 1850–2000 for whites and blacks using the procedure of Murphy, Simon and Tamura (2008).

the national increase in schooling, or comparing percentage increase in schooling with the national percentage increase in schooling. As with whites, the divisions with larger baby booms were also those with smaller increases in schooling years.

Although the Baby Boom is not the primary focus of the current paper, it is worth pointing out that for every division the white Baby Boom 1970 cohort enjoys

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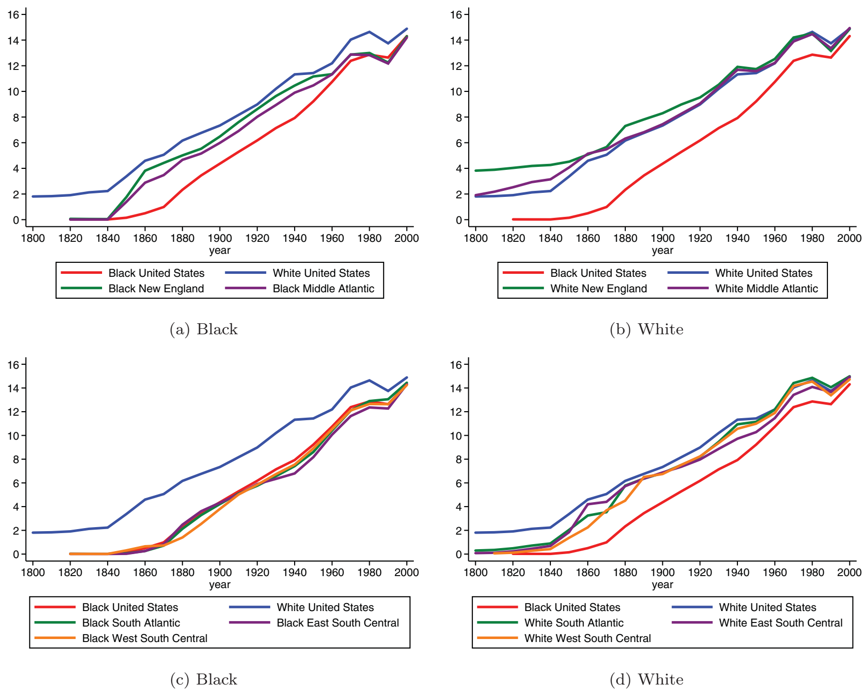

FIGURE 4. (Colour online) Cohort black and white schooling.

a higher level of schooling than any prior white cohort. An identical pattern holds for blacks. That the rise in fertility during the Baby Boom for both races was not accompanied by a decline in schooling is a challenge for any model of fertility that incorporates a quantity–quality tradeoff (Becker and Lewis 1973; Becker, Murphy and Tamura 1990). We will accomplish this feat in our model via the schooling efficiency parameter.[7]

1.4. Mortality

Our data on mortality are collected from life tables of so-called “death registration states,” available for selected states starting in 1890 and becoming available for almost all states by 1920. For years not covered in the life tables, we combined information on (potentially error-ridden) reported deaths in the decennial Censuses with our own back-forecasts of state-specific mortality, described in the Appendix. The resulting data series begin in 1800 for whites and in 1820 for blacks.

The mortality data are graphed in Figures 6–9; infant mortality are graphed in Figures 6 and 7. Probabilitiy of dying before age 15 years, are graphed in Figures 8 and 9.[8] Dramatic declines in mortality across all divisions are evident, as is a convergence in mortality across Census divisions. The higher mortality observed

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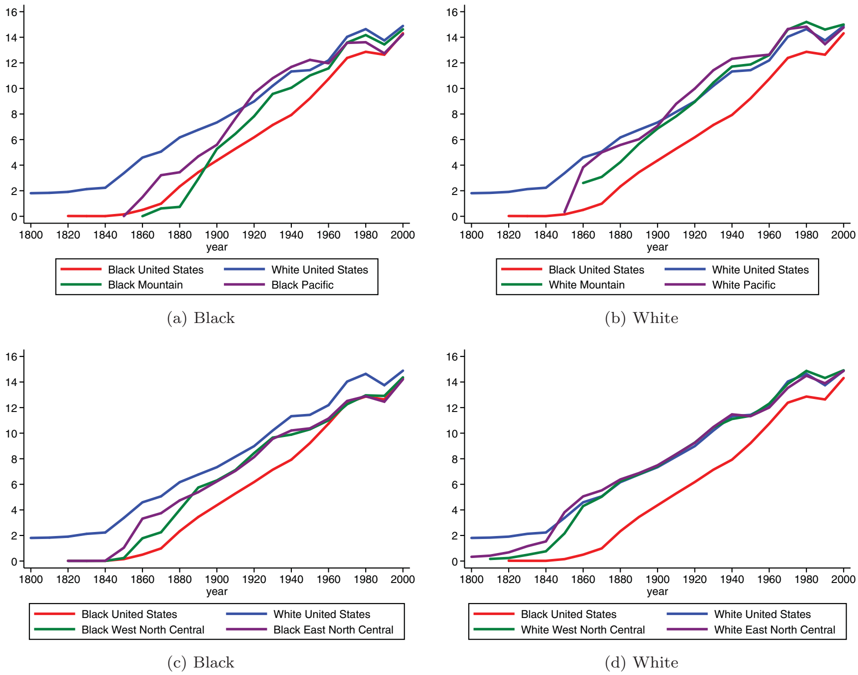

FIGURE 5. (Colour online) Cohort black and white schooling.

among northerners reflects the impact of urbanization, with its accompanying problems of waste disposal, lack of sewer and water treatment, and generally high density and sanitation problems documented by McNeill (1977), Melosi (1999), and Troesken (2004).

2. MODEL

Our model is designed to match time series on fertility and years of schooling over time and across states, for blacks and whites. Although we wish to explain differences in schooling outcomes for blacks and whites, our focus on just these two variables leads us to adopt a framework that abstracts from institutional detail. In our model, parents choose their consumption, the amount of space for each child, the number of children born and child quality, given the constraints imposed by their initial human capital stock, the probability of child survival, the price of living space, and most importantly for our purposes, the efficiency of resources – here, time – devoted to schooling.

TABLE 4. Changes in average years of schooling: By census division and race

Division	Absolute change from 1950 to 1970	Relative to national change	Percentage change from 1950	Relative to national percentage change
		White		
NE	2.46	0.95	21.0	0.92
MA	2.32	0.89	20.0	0.88
SA	3.27	1.25	29.3	1.28
ESC	3.14	1.20	30.5	1.34
WSC	3.17	1.22	28.9	1.27
MTN	2.73	1.05	21.8	1.01
PAC	2.15	0.82	17.2	0.75
WNC	2.50	0.96	22.0	0.97
ENC	2.21	0.85	19.5	0.86
US	2.61		22.8	
		Black		
NE	1.71	0.54	15.3	0.45
MA	2.41	0.76	23.0	0.67
SA	3.50	1.11	40.6	1.19
ESC	3.46	1.10	42.4	1.24
WSC	3.20	1.01	36.0	1.05
MTN	2.57	0.81	23.4	0.68
PAC	1.33	0.42	10.9	0.32
WNC	1.96	0.62	19.0	0.56
ENC	2.14	0.68	20.7	0.60
US	3.16		34.3	

Table reports both absolute, proportionate, and relative change in schooling during the Baby Boom, by race. In each relative case, we report the changes in comparison to the national change by race.

2.1. Preferences

A parent of race R belonging to cohort t and living in state i chooses consumption c_{iRt}, gross fertility x_{iRt}, living space (per child) S_{iRt}, and human capital investment (also per child) h_{iRt+1} in order to maximize:

$$\alpha \left(c_{iRt}^{\psi} S_{iRt}^{1-\psi}\right)^{\varphi} [(1-\delta_{iRt})x_{iRt} - a]^{1-\varphi} + \Lambda h_{iRt+1}^{\varphi}\left(1 - \frac{\beta_{iRt}\delta_{iRt}^{\nu_{iRt}}}{[(1-\delta_{iRt})x_{iRt} - a]\,(1-\delta_{iRt})}\right), \tag{2}$$

where δ_{iRt} is young adult mortality, and in order to place a lower bound on fertility, $a \geq 0$.[9] Ideally, we would assume that all individuals have identical preferences, regardless of race or state of residence. Originally, we had identical preferences by race and census cohort. Thus, blacks and whites may have different preference parameters (β_{Rt}, ν_{Rt}), where R refers to race, and t to census cohort.

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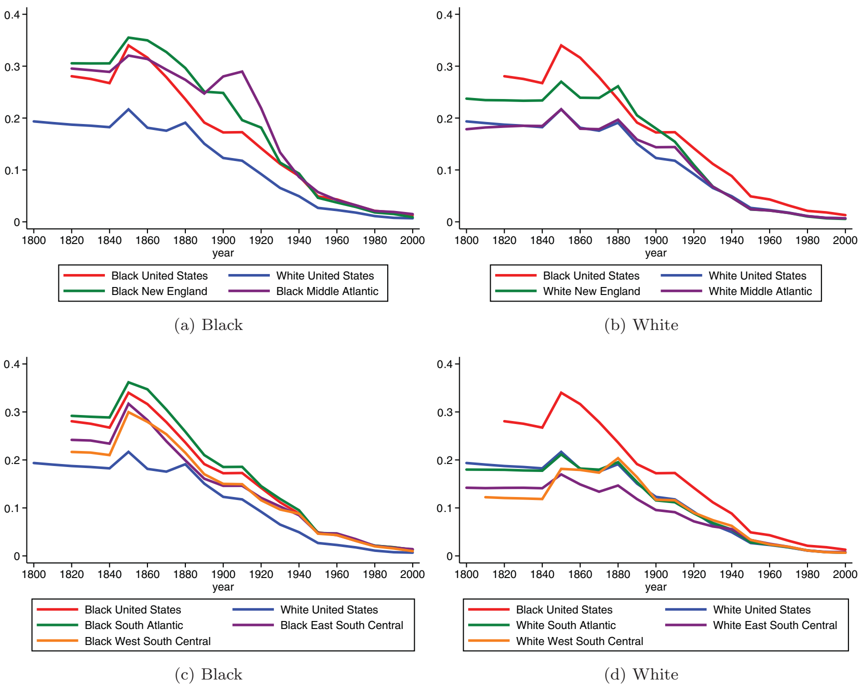

FIGURE 6. (Colour online) Cohort black and white infant mortality.

In this specification, we were able to fit the national time series of black and white fertility separately. However, the years of schooling fit by race were not that good, and when we examined the census divisions separately, as well as each state separately, the schooling fit was poor. Since the focus of the paper is to measure the welfare cost of unequal schooling access, we felt it more important to fit schooling as well as fertility, compared with maintaining identical preferences by race and cohort. Although we were unable to produce sufficiently accurate predictions imposing identical parameters, the only heterogeneity in preferences that we allow are in (β_{iRt}, ν_{iRt}), which relate to the precautionary demand for children. Because precautionary demand vanishes as mortality approaches to zero, blacks and whites therefore have identical preferences in the limit. Thus, preference parameters $(\alpha, \psi, \varphi, a, \Lambda)$ are identical across race, state, or birth cohort. Two of these parameters (a, Λ) are fixed by the other taste parameters, technological parameters and stationary solution values of schooling and fertility. These are presented below in subsection 2.5 Model solution. After we present the rest of the model, human capital accumulation technology, the parental budget constraint, we describe how the (β_{iRt}, ν_{iRt}) are chosen to fit the data in Section 3.

The fertility and human capital investment decision is similar to the one in Jones (2001), in which declining mortality induces a demographic transition.

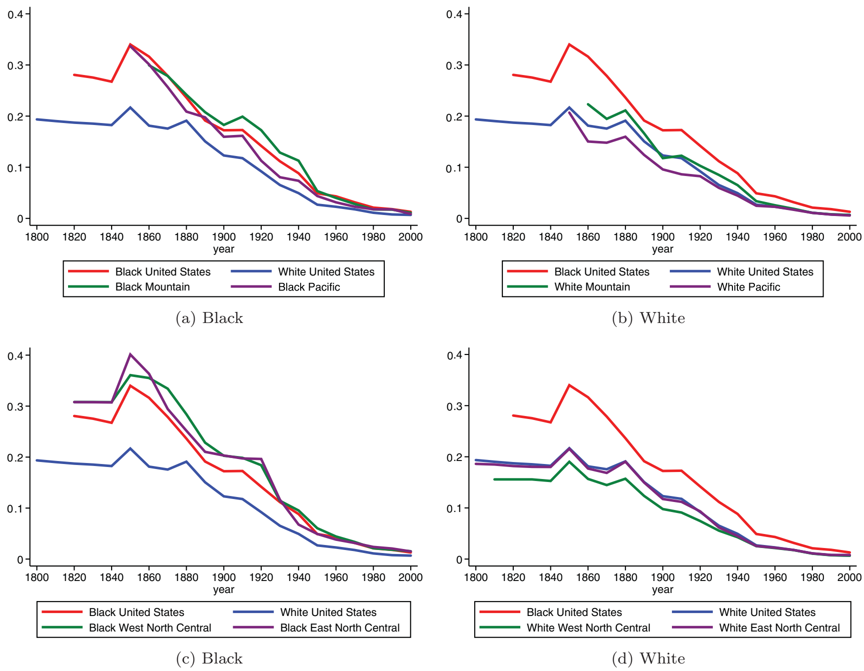

FIGURE 7. (Colour online) Cohort black and white infant mortality.

However, in contrast to Jones (2001), in which the decline in mortality arises due to rising consumption, we take the decline in mortality as parametric. Allowing for endogenous mortality, as in (Tamura 2006), complicates the fitting exercise considerably. Below, we will calculate the value that blacks would have received had they enjoyed access to the same schooling technology as whites, holding constant mortality. Allowing mortality to be a function of schooling would therefore likely increase this value.

Higher human capital investment (h_{iRt+1}) raises parental utility directly, but is assumed (as seems intuitive) to increase the disutility of child mortality. The precautionary demand for children is similar to that in Kalemli-Ozcan (2002, 2003) and Tamura (2006). Higher mortality δ_{iRt} reduces utility both directly, in the final term, and indirectly by reducing net fertility below gross fertility x_{iRt}. Declining mortality reduces gross fertility, and in the limit the final term disappears as mortality approaches zero.

2.2. Technology of Human Capital Accumulation

The law of motion for human capital is given by

$$h_{iRt+1} = A\overline{h}_t^{\rho_t} h_{iRt}^{1-\rho_t} \tau_{iRt}^{\mu} \tag{3}$$

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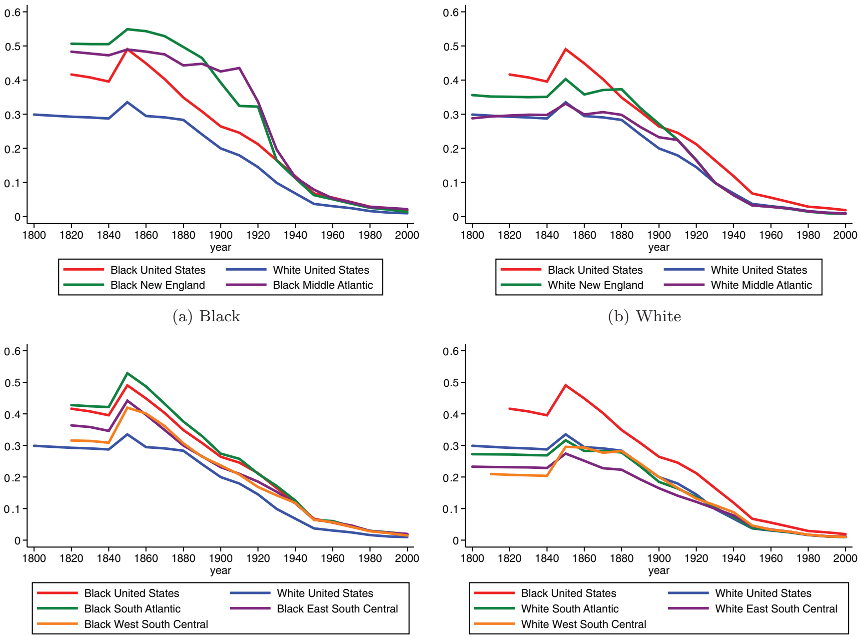


(a) Black (b) White

(c) Black (d) White

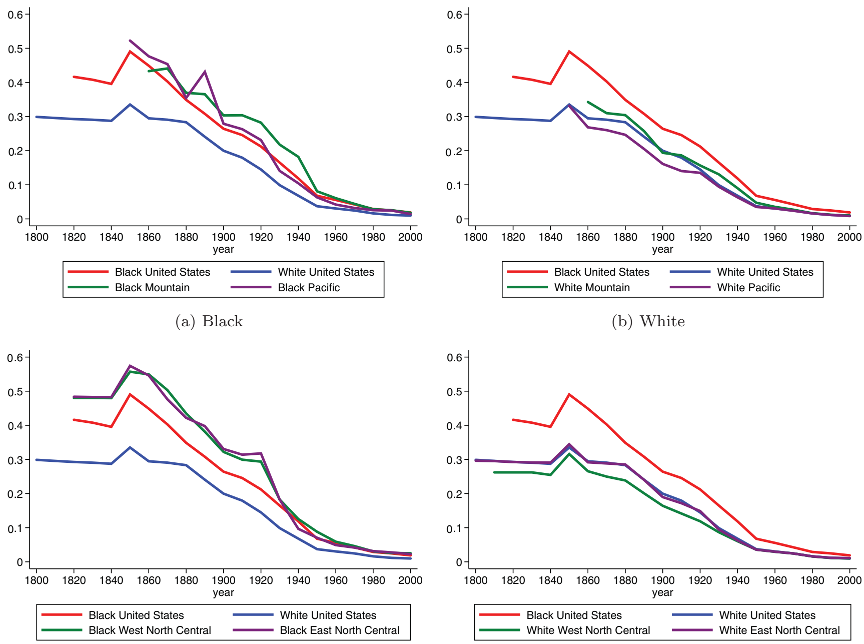
FIGURE 8. (Colour online) Cohort black and white mortality before 15.

$$\rho_t = min\left\{.5, \frac{.5\overline{\tau}_t}{.38125}\right\}. \quad \textbf{(4)}$$

Parents choose the amount of time to devote to educating their child, τ_t, which we identify with years of schooling. The productivity of this time is positively related to (a) the (unobserved) existing stock of their human capital, h_{iRt} and (b) the (also unobserved) frontier level of human capital in the economy, $\overline{h}_t$. The term $\overline{h}_t$ introduces a human capital spillover whose strength is governed by ρ_t and permits us to generate the convergence of human capital levels seen in the data. Parents are assumed to have perfect foresight regarding the effect of $\overline{\tau}_t$ on ρ_t but ignores the effect of their choice of τ_t on $\overline{\tau}_t$, ρ, and $\overline{h}_t$.[10]

The parametric form for ρ_t in equation (4) is similar to Tamura (2006). We assign each period a calendar duration of 40 years, so $40\tau_t$ is equal to the average number of years of schooling we observe for a representative member of birth cohort t. To see how this works, suppose that we observe identical years of schooling equal to 12 years in two states that start out with different initial (unobserved) human capital stocks h_{it}. This implies $\tau_t = \frac{12}{40} = 0.3$, ρ_t=0.3934, and 1–ρ_t=0.6066. The ratio of human capital in the two states after 1 period is therefore equal to

$$\frac{h_{it+1}}{h_{jt+1}} = \left(\frac{h_{it}}{h_{jt}}\right)^{0.6066}. \quad \textbf{(5)}$$



(a) Black (b) White

(c) Black (d) White

FIGURE 9. (Colour online) Cohort black and white mortality before 15.

Because income is proportional to human capital, this implies a rate of income convergence of $1 - 0.6066^{0.025} = 1.24\%$ per year. At 15.25 years of schooling, $\tau_t = 0.38125$, $\rho = 0.5$, and convergence is 1.7% per year. Finally, at eight years of schooling, $\tau_t = 0.2$, $\rho_t = 0.2623$, and convergence is only 0.76% per year. A maximum value of ρ_t of 0.5 seems consistent with the rate of income convergence of 1–2% per year observed in the data.[11]

2.3. The Parental Budget Constraint

The parent's budget constraint requires that total consumption be equal to income. The budget constraint is given by

$$pc_{iRt} + r_{iRt}x_{iRt}S_{iRt} = h_{iRt}\left[1 - x_{iRt}\left(\theta + \kappa_{it}^{R}\tau_{iRt}\right)\right], \tag{6}$$

where p is the price of consumption, child rearing takes a fixed proportion of time per child, θ, and r_{iRt} is the unit price of living space (per child) S_{iRt}, included to capture the Baby Boom.[12] Parents divide their time between the labor market and raising children.

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2.4. The Key Parameter: Schooling Efficiency

Unequal access to schooling was arguably the most important manifestation of racial discrimination against blacks in the US after the end of slavery, (Margo 1990; Canaday and Tamura 2009).[13] We assume that unequal access to schooling is manifested in the model via the parameter κ_t, which governs the (in)efficiency of schooling time. Because the total time cost of educating one's children is $\kappa_t \tau_t$, higher values of κ_t require greater diversion of time away from the labor market to produce a given level of human capital investment in one's children.

Our method of parameterizing discrimination is convenient, and we have used it in other work.[14]

2.5. Model Solution

Ignoring state i and race R subscripts for simplicity, substitute equations (3) and (6) into equation (2) and differentiate to produce the three Euler conditions governing fertility x_t, human capital investment h_{t+1}, and living space S_t:[15]

$$\frac{\partial}{\partial \tau} : \frac{\psi \alpha c_t^{\psi\varphi-1} S_t^{(1-\psi)\varphi}\left[(1-\delta_t)x_t - a\right]^{1-\varphi}}{p} = \frac{\Lambda \mu A^{\varphi}(\overline{h}_t^{\rho} h_t^{1-\rho})^{\varphi} \tau_t^{\mu\varphi-1}\left(1 - \frac{\beta_t \delta_t^{\nu_t}}{[(1-\delta_t)x_t - a](1-\delta_t)}\right)}{h_t x_t \kappa_t} \tag{7}$$

$$\frac{\partial}{\partial x} : \psi\varphi\alpha c_t^{\psi\varphi-1} S_t^{(1-\psi)\varphi}\left[(1-\delta_t)x_t - a\right]^{1-\varphi} \frac{h_t\left[\theta + \kappa_t\tau_t\right] + r_t S_t}{p} = (1-\varphi)\alpha c_t^{\psi\varphi} S_t^{(1-\psi)\varphi}\left[(1-\delta_t)x_t - a\right]^{-\varphi}(1-\delta_t) + \Lambda h_{t+1}^{\varphi} \frac{\beta \delta_t^{\nu_t}}{[(1-\delta)x_t - a]^2} \tag{8}$$

$$\frac{\partial}{\partial S} : \psi\varphi\alpha c_t^{\psi\varphi-1} S_t^{(1-\psi)\varphi}\left[(1-\delta_t)x_t - a\right]^{1-\varphi} \frac{r_t x_t}{p} = \alpha(1-\psi)\varphi c_t^{\psi\varphi} S_t^{(1-\psi)\varphi-1}\left[(1-\delta_t)x_t - a\right]^{1-\varphi}. \tag{9}$$

Using (9) to solve for c_t as a function of S_t and x_t yields

$$c_t = \left(\frac{\psi}{1-\psi}\right)\frac{r_t x_t S_t}{p}. \tag{10}$$

Substituting for c_t in the budget constraint produces

$$r_t x_t S_t = (1-\psi) h_t \left[1 - x_t(\theta + \kappa_t \tau_t)\right]. \tag{11}$$

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Substituting the budget constraint into the utility function gives the new maximand:

$$v\left(h_t|\kappa_t, r_t\right) = \max_{x_t,\tau_t} \left\{ \begin{array}{c} \alpha \left(\frac{\psi}{p}\right)^{\psi\varphi} \left(\frac{1-\psi}{r_t x_t}\right)^{(1-\psi)\varphi} \left(h_t\left[1 - x_t\left(\theta + \kappa_t\tau_t\right)\right]\right)^{\varphi} \\ \times\left[\left(1-\delta_t\right)x_t - a\right]^{1-\varphi} \\ +\Lambda\left(A\overline{h}_t^{\rho_t} h_t^{1-\rho_t}\tau_t^{\mu}\right)^{\varphi}\left(1 - \frac{\beta_t\delta_t^{\nu_t}}{(1-\delta_t)[(1-\delta_t)x_t - a]}\right) \end{array} \right\}. \qquad \textbf{(12)}$$

Because fertility x_t interacts with S_t and h_{t+1}, the budget constraint (6) is not convex and thus (12) need not be globally concave. It is therefore not feasible to derive analytically tractable comparative statics.[16] However, conditional on fertility, the problem is concave in the remaining choice variables. We therefore solve the model in the same way as in Tamura (2006), and Tamura and Simon (2015), by constructing a grid of fertility values that range from $\frac{a}{1-\delta_t}$ to the biological maximum of $\frac{1}{\theta}$, solving for the remaining choice variable $\tau_t(x_t)$, and choosing the level of fertility that yields the highest level of utility.[17]

However, before going to the numerical solutions, there are a pair of parameter restrictions that we impose on preferences, (a, Λ). In other words, we impose these restrictions in order to calibrate from the balanced growth path with zero mortality, constant price of consumption, p, constant rental price of space, r, and a fixed population. Thus, fertility is equal to one, $x = 1$, and a constant schooling time, $\overline{\tau}$. Under these assumptions, (a, Λ) must satisfy

$$a = 1 - \frac{(1-\varphi)(1-\theta-\overline{\tau})}{\varphi[1-\psi(1-\theta-\overline{\tau})]} \qquad \textbf{(13)}$$

$$\Lambda = \frac{\alpha\psi^{\psi\varphi}(1-\psi)^{(1-\psi)\varphi}(1-a)^{1-\varphi}\overline{\tau}^{1-\mu\varphi}}{\mu(Ap^{\psi}r^{1-\psi})^{\varphi}(1-\theta-\overline{\tau})^{1-\varphi}}. \qquad \textbf{(14)}$$

3. NUMERICAL SOLUTIONS

Table 5 contains the common calibrated parameters in the model. Most of the choices are standard. For example, the time cost of rearing a child, $\theta = 0.125$ implies a biological maximum fertility of 8 in an asexual model, or 16 in a model with males and females. With a period of 40 years, it also implies that a child is 5 years old when he or she enters school. Our choice of $\overline{\tau} = 0.38125$ implies a steady state value of 15.125 years of schooling.[18] Finally, our choice of price of space per child is a bit more difficult. Our chosen value is the average value of white population density of US states in 2000, where we weight the states by their white population.

Our choice for (A, μ) is consistent with a annualized balanced growth path growth rate of 1.80%.[19] Our choice of parameters (θ, ψ) together with our calibrated long run values of fertility and schooling, $x = 1$, $\overline{\tau} = 0.38125$, and our assumed stationary value of $\kappa = 1$, imply a stationary budget share for space or

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TABLE 5. Parameter values & calibration

Parameter	Value	Parameter	Value	Parameter	Value
α	0.275	μ	0.085	A	1.55
ψ	0.660	$\overline{\tau}$	0.38125	p	1.000
φ	0.550	a	0.40073833	r	1.529679
θ	0.125	Λ	1.0168298		

Calibration

Variable	Model	White	Black	National	notes
Fertility	2.00	2.01	2.20		1998–2004 CPS Supplement
Schooling	15.25	14.89	14.31		enrollment rates though 2011
Annualized growth rate	1.80%			1.80%	1840–2000[1]
Housing share	0.19			0.19	US value[2]
Next generation share	0.44			0.48	
				0.21	avg 1950–2011 US investment rate[3]
				0.08	US public & private education rate[4]
				0.05	US 0–44 pop health expenditures[5]
				0.02	US R&D net of university[6]
				0.12	foregone earnings: schooling beyond 12 years[7]

Parameter values that are constant throughout the solution. The value of a and Λ are determined by the other parameters and are given by (13) and (14), respectively. We assume that consumption is the numeraire. The value of r is the average white state density for 2000, where we weighted by the 2000 white population. [1]For the model, we assumed that the growth rate is computed as $\ln(A\overline{\tau}^{\mu})/20$. Annualized growth of real output per worker from 1840–2000, Turner, Tamura and Mulholland (2010). [2]*OECD Better Life Index*. [3]*Penn World Tables*. [4]*Digest of Education Statistics* [5]Lassman, et al. [6]Figure comes from WDI less R&D expenditures by universities, the latter figure from *Chronicle of Higher Education Almanac issue 2013–14*. [7]Authors' calculations using a 4.5% discount rate, \$31,700 median full time male worker earnings of high school graduates (25–34 years old), and \$41,700 median full-time male worker earnings of workers with an Associate Degree (25–34 years old).

housing, S, of about 19%.[20] This is the US housing budget share reported in the *OECD Better Life Index*, and compares with the OECD average of 21%. All other consumption expenditure share comes from (10) and is about 37%. Thus, total consumption in the model is 56% of measured income, with the rest, 44% spent on schooling. This is obviosly much higher than the US data. Of course in the model there is no physical capital, so all investment for the next generation comes from human capital accumulation. If we use the 21% physical capital investment share of GDP (from *PWT*), 7.8% total public and private education share of GDP (from *Digest of Education Statistics*) and share of health expenditures on the population 0–44 (763 out of 2193) on GDP of 14958.3 or 5.1% (from *US Health Spending Trends by Age and Gender: Selected Years 2002–10* by Lassman, Hartman, Washington, Andrews and Catlin), and total public and private R&D expenditures as share of GDP 2.74% or $410 billion less $60 billion spent by higher education. Thus, something like $350 billion of R&D are not spent by higher education institutions, or 2.3%. Combining these four produces, a next generation expenditure share of 36.2%. We assume that the first 12 years of schooling has no opportunity cost for the child. We compute the opportunity cost of the 3.25 additional years of schooling in the following manner. We used the year 2013 $31,700 median annual earnings of full time high school graduate male workers, ages 25–34 years. For an economy with 15.25 years of schooling, we assumed these workers earn the year 2013 $41,700 median annual earnings of full time Associate Degree male workers, ages 25–34 years. Using a 4.5% annual discount rate, we find that the foregone earnings are equal to 18% of lifetime earnings of Associate Degree workers. With a labor share of $\frac{2}{3}$, this produces a foregone earnings cost of 12%. We thus arrive at 48% share of GDP spent on the next generation.[21] We summarize our calibration measures in the bottom panel of Table 5. Thus, our stationary values of fertility, schooling, consumption, housing, and next generation expenditures are close to those observed in the US data.

A brief description about the "calibration exercise" for choice of β_{iRt}, ν_{iRt}, and κ_{it}^R is useful. The parameters β_{iRt}, ν_{iRt}, and κ_{it}^R are chosen to fit the race specific data on fertility and cohort years of schooling as closely as possible. We will show below that assuming divisional or national preferences by race and cohort, still fit their respective data extremely well, and the welfare costs of unequal schooling access are very similar to those from state, race, and cohort specific preferences. Although we expected to find higher average values of κ_{it}^R (that is, lower schooling efficiency) for blacks than for whites for most of the years, no effort was made to ensure $\kappa_{it}^w < \kappa_{it}^b$. We followed a two step procedure to fit state, cohort and race specific fertility and schooling. First, the preference pair β_{iRt}, ν_{iRt} are not separately identified; they always appear together as $\beta_{iRt}\delta_{iRt}^{\nu_{iRt}}$. The major discipline that we imposed on our calibration exercise was to force $\nu = 0.5$ for all years 1950–2000. Otherwise, we allowed β_{iRt} and ν_{iRt} to vary. This procedure allowed us to match fertility by state, race, and cohort specific fertility. The second step was to search for κ_{it}^R in order to match the state, race, and cohort specific schooling. Typically, there was little feedback from changing values of κ on fertility. However, if there was sufficient feedback, we then returned to β_{iRt} and ν_{iRt} to match state, race, and cohort fertility for the κ_{it}^{R}. Then, we returned to the fit of schooling. Generally, this iterative process converged to triple, $(\beta_{iRt}, \nu_{iRt}, \kappa_{it}^{R})$ that fit both fertility and schooling. Our method of "identifying" κ_{it}^{b} and κ_{it}^{w} is similar to the pioneering work of Mulligan (2004, 2005).

We compute welfare costs of unequal access to schooling using three sets of (β, ν) parameters. Our preferred method allows for full state, race, and cohort heterogeneity in the parameters, (β_{iRt}, ν_{iRt}), where i ranges over 1–51. The second method aggregates race preferences within census divisions, weighting by the appropriate race populations within the census division, (β_{dRt}, ν_{dRt}), where d ranges over 1–9, the nine census divisions:

$$\beta_{dRt} = \frac{\sum_{j\in d} \beta_{jRt}\, pop_{jRt}}{\sum_{j\in d} pop_{jRt}}, \tag{15}$$

$$\nu_{dRt} = \frac{\sum_{j\in d} \nu_{jRt}\, pop_{jRt}}{\sum_{j\in d} pop_{jRt}}, \tag{16}$$

where state j is in census division d. The third method aggregates race preferences nationally, allowing for time variation across cohorts. Thus, we produce

$$\beta_{Rt} = \frac{\sum_{j=1}^{51} \beta_{jRt}\, pop_{jRt}}{\sum_{j=1}^{51} pop_{jRt}}, \tag{17}$$

$$\nu_{Rt} = \frac{\sum_{j=1}^{51} \nu_{jRt}\, pop_{jRt}}{\sum_{j=1}^{51} pop_{jRt}}. \tag{18}$$

For all preference specifications, we used the κ_{it}^{R} calibrated to state, race, and cohort preferences to measure the welfare cost of unequal education access.

Before presenting the our estimates of κ_{it}^{R}, we present the goodness of fit of all three models in matching the respective race and cohort fertility and schooling. Table 6 presents the fit of our solutions with the data. In the first three columns of the table, we compare the log of US national aggregate time series for white, black fertility, and white and black schooling with the log of aggregated solution values for nation preferences, division preferences, and state specific preferences, where the weights are the observed state, race specific, and cohort specific populations. We regressed the log of the actual time series against the log of the model aggregated time series. For the US aggregate series, we corrected for serial correlation

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TABLE 6. Regressions of log actual observations on log model solutions

	US Aggregate			Census division aggregate	
	Nation preferences	Division preferences	State preferences	Division preferences	State preferences
			White fertility		
β	0.9525***	1.0286***	1.0025***	1.0045***	1.0085***
	(0.0794)	(0.0325)	(0.0116)	(0.0157)	(0.0068)
α	0.0001	– 0.0747	– 0.0089	– 0.0472**	– 0.0197*
	(0.1290)	(0.0505)	(0.0174)	(0.0237)	(0.0107)
N	21	21	21	176	176
$\bar{R}^2$	0.9461	0.9913	0.9988	0.9735	0.9945
p	0.4690	0.2221	0.7413	0.0000	0.0818
			White schooling		
β	0.5514***	1.0079***	1.0005***	1.0259***	1.0338***
	(0.0800)	(0.0417)	(0.0006)	(0.0128)	(0.0056)
α	0.7957**	– 0.0302	– 0.0031**	– 0.0643	– 0.0727
	(0.3264)	(0.0833)	(0.0011)	(0.0265)	(0.0118)
N	21	21	21	176	176
$\bar{R}^2$	0.2044	0.9351	1.0000	0.9700	0.9957
p	0.0001	0.8916	0.0001	0.0517	0.0000
			Black fertility		
β	1.2195***	1.0153***	0.9994***	0.8657***	0.9734***
	(0.0414)	(0.0587)	(0.0019)	(0.0560)	(0.0345)
α	– 0.4547	– 0.1078	– 0.0003	0.0640	0.0059
	(0.0682)	(0.1066)	(0.0029)	(0.0919)	(0.0579)
N	19	19	19	164	164
$\bar{R}^2$	0.9812	0.9713	0.9999	0.7410	0.8746
p	0.0000	0.3576	0.3164	0.0000	0.1061
			Black schooling		
β	0.8684***	0.8904***	0.9587***	0.8720***	0.9080***
	(0.0620)	(0.0454)	(0.0085)	(0.0265)	(0.0195)
α	0.0225	– 0.0101	0.0711***	0.1231	0.1398***
	(0.2389)	(0.2790)	(0.0237)	(0.0863)	(0.0543)
N	19	19	19	164	164
$\bar{R}^2$	0.9037	0.9457	0.9985	0.8617	0.9356
p	0.1352	0.0818	0.0002	0.0000	0.0000

Table reports results from pooled regressions with errors corrected for panel autocorrelation and Prais–Winsten heteroskedastic error correction. The final row, marked p, is the p-value on the null hypothesis that $\beta = 1$ and $\alpha = 0$.

and report robust standard errors. With the exception of white schooling, the nation preference model fits the data well. As we allow for more heterogeneity in (β_{Rt}, ν_{Rt}), the fit to the US aggregate series improves. The final two columns present the results of division aggregate values of each of the four series. When there are states present in all nine census divisions for census year t, there are

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TABLE 7. Pooled regressions of log actual observations on log model solutions: State preferences

	Base	Pre 1900	Post 1890	Pre 1960	Post 1940
			White fertility		
β	0.9941***	0.9625***	0.9853***	0.9928***	0.9217***
	(0.0078)	(0.0181)	(0.0098)	(0.0089)	(0.0265)
α	– 0.0134	0.0579*	– 0.0094	– 0.0066	0.0293
	(0.0120)	(0.0349)	(0.0118)	(0.0151)	(0.0194)
N	891	342	549	636	304
$\bar{R}^2$	0.9570	0.9586	0.9493	0.9678	0.8587
p	0.0005	0.0236	0.0038	0.0051	0.0004
			White schooling		
β	1.0319***	1.0479***	0.9880***	1.0367***	0.9542***
	(0.0077)	(0.0163)	(0.0041)	(0.0104)	(0.0144)
α	– 0.0700***	– 0.0674***	0.0252**	– 0.0706***	0.1133***
	(0.0160)	(0.0233)	(0.0099)	(0.0192)	(0.0369)
N	891	342	549	636	304
$\bar{R}^2$	0.9760	0.9661	0.9853	0.9697	0.9900
p	0.0001	0.0097	0.0001	0.0010	0.0008
			Black fertility		
β	0.9730***	0.9403***	1.0012***	0.9678***	0.9967***
	(0.0146)	(0.0694)	(0.0063)	(0.0226)	(0.0064)
α	0.0132	0.0392	– 0.0069	0.0053	0.0013
	(0.0223)	(0.1309)	(0.0075)	(0.0369)	(0.0056)
N	843	294	549	588	304
$\bar{R}^2$	0.9059	0.7668	0.9861	0.8844	0.9938
p	0.0000	0.0337	0.0447	0.0005	0.2501
			Black schooling		
β	0.8530***	0.7977***	1.0024***	0.8394***	0.9962***
	(0.0103)	(0.0200)	(0.0019)	(0.0128)	(0.0045)
α	0.2255***	– 0.0455	– 0.0071	0.1658***	0.0082
	(0.0303)	(0.0740)	(0.0044)	(0.0395)	(0.0109)
N	843	294	549	588	304
$\bar{R}^2$	0.8995	0.8597	0.9984	0.8901	0.9867
p	0.0000	0.0000	0.0082	0.0000	0.1208

Table reports results from pooled regressions with errors corrected for panel autocorrelation and Prais–Winsten heteroskedastic error correction. The final row, marked p, is the p-value on the null hypothesis that $\beta = 1$ and $\alpha = 0$.

nine different observations in year t. We would not expect nation preferences to fit these series, so we only report the goodness of fit regressions from division preferences and state preferences. Again the fit is quite good; these regressions are the results from pooled regressions with correction for panel serial correlation. We report robust standard errors.

Finally, Table 7 presents the goodness of fit of the model with the actual state, race, and cohort observations in the data for the full model with (β_{iRt}, ν_{iRt}), that is

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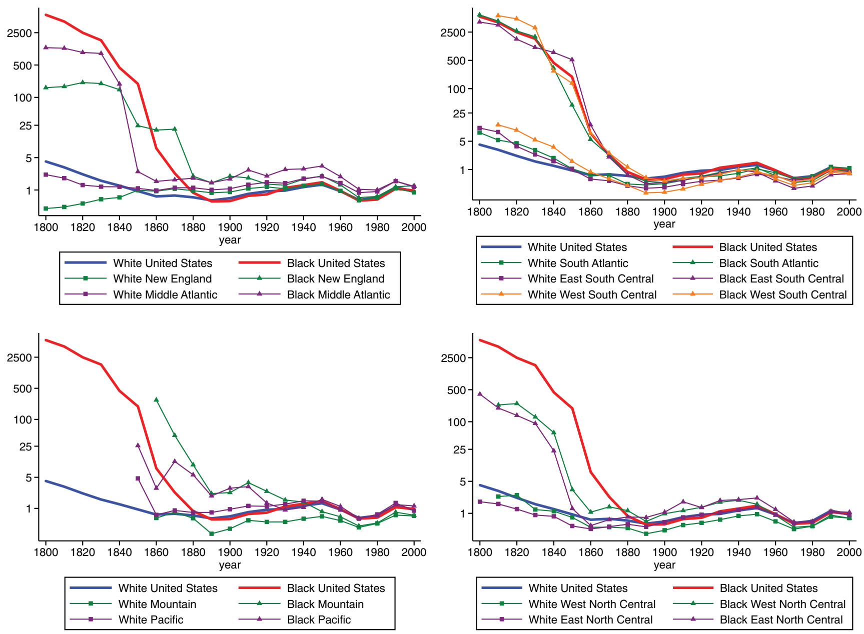

FIGURE 10. (Colour online) Black and white cost of schooling, $\kappa_t^{b,w}$.

state preferences. As before, we regress the log of the actual values of white, black fertility, and white, black schooling. The table reports the results from pooled regressions, with errors corrected for panel serial correlation and robust standard errors. We are comfortable with the ability of the model to capture each state, race, and cohort fertility and schooling. The model fits the entire time series for each series well, c.f. first column. The typical $\overline{R}^2$ is 0.90 or better. The slope coefficient is close to 1, and the intercept relatively small.[22] The model can fit separate periods well; these are pre 1900, 1900–2000, pre 1950, and 1950–2000. In the 16 regressions reported in Table 7, only one fails to deliver an $\overline{R}^2$ of better than 0.85. The average $\overline{R}^2$ in these 16 regressions is 0.9383. The average absolute value deviation from 1 of the slope coefficient is 0.045.[23] The average absolute value of the intercept is 0.0387.[24] Another indication of the success of our fit is that the ratio of black human capital to white human capital predicted by our model is 0.54 in 2000 and 0.62 in 2010. The corresponding values for relative black–white earnings for full-time working males who are age 25–64 years and who live in their birth state are 0.59 and 0.57, quite close to our predictions. We believe that Tables 5, 6, and 7 provide strong evidence that the model fits the data well.

The fitted values of κ_t^b and κ_t^w are shown in Figure 10 and reported in Table 8 by race, year, and census division. The cost of schooling for blacks was prohibitive prior to 1820. As late as 1860, southern black children acquired less than 0.5

TABLE 8. Population weighted average schooling costs: κ^b, κ^w

Year	NE	MA	SA	ESC	WSC	MTN	PAC	WNC	ENC	US
1800	162, 0.4	1186, 2.1	6675, 8.2	4432, 11.	–	–	–	–	400, 1.8	6067, 4.1
1810	172, 0.4	1152, 1.8	4702, 5.4	3752, 8.4	6375, 13.	–	–	232, 2.3	199, 1.6	4351, 3.1
1820	209, 0.5	935, 1.3	2681, 4.4	1677, 3.8	5333, 9.4	–	–	249, 2.5	138, 1.2	2495, 2.2
1830	199, 0.6	890, 1.2	1924, 3.0	1050, 2.4	3215, 5.4	–	–	127, 1.2	92, 0.9	1712, 1.6
1840	147, 0.7	194, 1.2	322, 1.9	787, 1.6	274, 3.6	–	–	58, 1.1	23, 0.9	439, 1.2
1850	25, 1.0	2.5, 1.1	39, 1.0	521, 1.0	136, 1.6	–, –	26, 4.7	3.3, 0.8	1.3, 0.5	196, 0.9
1860	20, 0.9	1.5, 1.0	5.6, 0.7	13., 0.6	7.9, 0.9	273, 0.6	2.8, 0.7	1.1, 0.5	0.5, 0.5	8.0, 0.7
1870	21, 1.1	1.7, 1.1	2.2, 0.7	2.0, 0.5	2.6, 0.6	44, 0.8	11., 0.9	1.4, 0.5	0.7, 0.5	2.3, 0.8
1880	2.0, 1.0	1.8, 1.1	0.7, 0.4	0.7, 0.4	1.2, 0.4	10, 0.6	5.7, 0.8	1.1, 0.5	0.8, 0.6	0.9, 0.7
1890	1.4, 0.9	1.4, 1.0	0.5, 0.4	0.4, 0.3	0.6, 0.3	2.2, 0.3	1.9, 0.8	0.7, 0.4	0.8, 0.5	0.6, 0.6
1900	2.0, 0.9	1.7, 1.1	0.5, 0.4	0.5, 0.4	0.5, 0.3	2.3, 0.3	2.8, 1.0	1.0, 0.4	1.1, 0.6	0.6, 0.7
1910	1.8, 1.1	2.7, 1.3	0.6, 0.5	0.5, 0.4	0.6, 0.3	3.8, 0.5	3.1, 1.1	1.2, 0.6	1.8, 0.8	0.8, 0.8
1920	1.3, 1.2	2.0, 1.5	0.7, 0.7	0.7, 0.5	0.6, 0.4	2.4, 0.5	1.3, 1.1	1.4, 0.6	1.3, 0.9	0.8, 0.9
1930	1.3, 1.1	2.8, 1.4	0.9, 0.7	0.8, 0.5	0.8, 0.5	1.5, 0.5	1.3, 0.9	1.7, 0.7	1.9, 1.0	1.1, 1.0
1940	1.7, 1.2	2.9, 1.8	0.9, 0.8	1.0, 0.6	1.0, 0.6	1.4, 0.6	1.1, 1.5	1.9, 0.9	2.0, 1.2	1.3, 1.2
1950	2.0, 1.3	3.3, 2.0	1.1, 1.0	0.9, 0.8	0.9, 0.9	0.8, 0.7	1.6, 1.5	1.6, 1.0	2.2, 1.3	1.5, 1.3
1960	1.3, 1.0	1.9, 1.4	0.7, 0.8	0.5, 0.7	0.6, 0.7	0.6, 0.5	1.1, 0.9	0.9, 0.7	1.2, 0.9	1.0, 0.9
1970	0.7, 0.6	1.0, 0.9	0.5, 0.6	0.3, 0.5	0.4, 0.5	0.4, 0.4	0.6, 0.6	0.5, 0.5	0.6, 0.6	0.6, 0.6
1980	0.7, 0.7	1.0, 0.9	0.5, 0.7	0.4, 0.6	0.5, 0.6	0.5, 0.5	0.7, 0.7	0.5, 0.5	0.7 0.7	0.6, 0.7
1990	1.2, 1.1	1.6, 1.6	1.0, 1.2	0.7, 0.9	0.8, 1.0	0.8, 0.7	1.2, 1.3	0.9, 0.8	1.1, 1.1	1.1, 1.1
2000	1.2, 0.9	1.2, 1.2	0.9, 1.1	0.8, 0.9	0.8, 0.8	0.7, 0.7	1.1, 0.9	0.8, 0.8	1.1, 0.9	1.0, 0.9

Table reports our estimates of the schooling access costs, κ^i, where $i = b, w$, averages are weighted by black and white populations, respectively.

years of schooling, compared with between 2 and 4 years of schooling for whites. Matters for blacks improved during Reconstruction, κ_t^b falling, and schooling among southern blacks rising to 2.5–3.5 years. Schooling for the 1950 cohort of southern blacks, those born in 1939, had reached 8–9 years, prior to the 1954 Brown vs. Board of Education decision, about 80% of the level achieved by whites. Average schooling of blacks exceeded 12 years as early as 1970, and by 2000 average black schooling exceeded 14 years, 95% or better of the level achieved by whites.[25]

The declining values in κ_t^R always lead to higher child quality, but need not induce substitution away from quantity. Indeed, our estimates indicate that declining κ_t^b helped to produce the black Baby Boom, despite a rise in population density (the price of living space) and despite declining child mortality. We see κ_t^b decline from 1.5 in 1950 to 1.0 in 1960, to 0.6 in 1970. By 1980, $\kappa_{1980}^b = 0.6$, but then reverses trend, rising to $\kappa_{1990}^b = 1.1$ in 1990 and levels off at $\kappa_{2000}^b = 1.0$ in 2000.

4. VALUING IMPROVEMENTS IN ACCESS TO SCHOOLING

Prior to the civil rights era, we find that $\kappa_t^b \geq \kappa_t^w$, indicating that blacks faced much higher schooling costs, or, equivalently, lower schooling efficiency than whites. In terms of our model, this means that for given levels of mortality, human capital stock, and the price of living space, blacks would have chosen counterfactually higher levels of schooling had they enjoyed parity in schooling efficiency.[26] The relative values of κ converge markedly during the civil rights era.

How much would blacks have been willing to sacrifice in order to face κ_t^w rather than κ_t^b? Denote the utility of a black parent in generation t with initial human capital stock h_t^b facing schooling efficiency κ_t^b and rental price of space r_t^b as $v(h_t^b|\kappa_t^b, r_t^b)$. Suppose that this parent faced the series (κ_t^w, r_t^b), thereby achieving utility level $v(h_t^b|\kappa_t^w, r_t^b)$. We can then answer the question by calculating the additional human capital, $h_t^b \Delta_t^b$, that must be transferred to blacks so that $v(h_t^b + h_t^b \Delta_t^b|\kappa_t^b, r_t^b) = v(h_t^b|\kappa_t^w, r_t^b)$. This quantity of human capital, equal to the equivalent variation, $h_t^b \Delta_t^b = EV_t^b$, is how we measure the welfare cost of discrimination against blacks in access to schooling.

There are three alternative measures of the welfare loss to differential schooling efficiency. The compensating variation for whites, were they to face the schooling efficiency faced by blacks is equal to $CV_t^w = h_t^w \Delta_t^w$, and solves $v(h_t^w + h_t^w \Delta_t^w|\kappa_t^b, r_t^w) = v(h_t^w|\kappa_t^w, r_t^w)$. The equivalent variation for whites, the amount a white parent would pay to avoid having black schooling efficiency, $EV_t^w = -h_t^w \Omega_t^w$, is implicitly defined as $v(h_t^w(1 - \Omega_t^w))|\kappa_t^w, r_t^w) = v(h_t^w|\kappa_t^b, r_t^w)$. Finally, the black compensating variation is the amount of wealth a black would have willingly given up to purchase the white schooling efficiency: $CV_t^b = -h_t^b \Omega_t^b$, defined implicitly as $v(h_t^b(1 - \Omega_t^b))|\kappa_t^w, r_t^b) = v(h_t^b|\kappa_t^b, r_t^b)$. We approximate the equivalent variations and compensating variations by taking advantage of the fact that for any (x_t, τ_t) pair, optimal adult consumption, c, and space per child, S, are linear functions of parental human capital, h. Thus, the utility function is homogeneous of degree φ in h.[27] Thus,

$$EV_t^b = h_t^b \Delta_t^b : \Delta_t^b \approx \left[\frac{v(h_t^b|\kappa_t^w, r_t^b)}{v(h_t^b|\kappa_t^b, r_t^b)}\right]^{\frac{1}{\varphi}} - 1 \quad \textbf{(19)}$$

$$CV_t^b = -h_t^b \Omega_t^b : -\Omega_t^b \approx \left[\frac{v(h_t^b|\kappa_t^b, r_t^b)}{v(h_t^b|\kappa_t^w, r_t^b)}\right]^{\frac{1}{\varphi}} - 1 \quad \textbf{(20)}$$

$$EV_t^w = -h_t^w \Omega_t^w : -\Omega_t^w \approx \left[\frac{v(h_t^w|\kappa_t^b, r_t^w)}{v(h_t^w|\kappa_t^w, r_t^w)}\right]^{\frac{1}{\varphi}} - 1 \quad \textbf{(21)}$$

$$CV_t^w = h_t^w \Delta_t^w : \Delta_t^w \approx \left[\frac{v(h_t^w|\kappa_t^w, r_t^w)}{v(h_t^w|\kappa_t^b, r_t^w)}\right]^{\frac{1}{\varphi}} - 1. \quad \textbf{(22)}$$

Table 9 reports estimates for all four welfare measures with state preferences. All measures are presented as a proportion of black wealth, and are averaged over the black population of each state. Thus for Δ^w and Ω^w, we multiply each state's welfare measure by $\frac{h_t^w}{h_t^b}$. The measures are presented over all years and for the five subperiods of our data: slavery (pre 1870), Reconstruction (1870 to 1890), Jim Crow (1900 to 1950), pre Civil Rights (pre 1960), and the Civil Rights era (1960 to 2000). We present the average results by Census division and for the US as a whole.

Prior to 1870, blacks are estimated to have needed an additional Δ_t^b=3.4 times their lifetime wealth to have the same utility they would have enjoyed with the same schooling efficiency as whites in the US as a whole. The estimated value of Δ_t^b varies widely across regions, ranging from a low of 0.18 in the West North Central to a high of 5.8 in the East South Central. Using division nation preferences and division preferences produces Δ_t^b equal to 2.9 and 2.8 times lifetime black wealth, respectively.[28] Thus, our results do not depend on preference heterogeneity.[29]

During Reconstruction, the equivalent variation actually rises to 4.7 in the US as a whole. The estimated value of Δ_t^b is lowest in New England, with a value of 0.60, and Δ_t^b rises in the East South Central to 6.8. The rise in Δ_t^b seems paradoxical in light of the absolute and relative decline in κ_t^b. The explanation lies in the differential mortality risk borne by blacks, which remained much higher than for whites. Young adult mortality fell among blacks from 50% prior to the Civil War to 42% during Reconstruction, while mortality among whites fell from 31% to 26%. The result is that black precautionary demand for children remained relatively high. Despite a decline in $\frac{\kappa_t^b}{\kappa_t^w}$ from 350 to 2.25, the still high precautionary fertility demand made the discrimination more costly, raising Δ_t^b.[30] Thus while both preferences produce rising welfare costs of unequal school access, they are much smaller than under state preferences. Welfare costs under nation preferences rise from 2.9 to 3.3, and they rise under division preferences from 2.8 to 3.0.

Black schooling efficiency is estimated to have improved during the Jim Crow era, Δ_t^b falling from 4.7 to 1.7 in the US as a whole, and from 6.8 to 2.8 in the East South Central.[31] The magnitude of the rise in black welfare seems a bit optimistic in light of the legal and social environment faced by blacks. To

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TABLE 9. Welfare cost of education discrimination, state preferences (no DC): Black compensating variation $-\Omega^b$, white equivalent variation $-\Omega^w$, white compensating variation Δ^w, black equivalent variation Δ^b (all as proportion of black life time wealth)

Years	Welfare	NE	MA	SA	ESC	WSC	MTN	PAC	WNC	ENC	US
All	$-\Omega^b$	−0.0777	−0.1198	−0.2709	−0.4401	−0.2585	−0.0646	−0.0145	−0.1775	−0.0993	−0.2435
All	$-\Omega^w$	−0.1280	−0.1602	−2.2467	−4.0678	−0.9561	−0.0735	−0.0037	−0.3849	−0.1009	−1.6908
All	Δ^w	0.1688	0.1933	2.7157	4.9239	1.1101	0.1111	0.0076	0.4352	0.1092	2.0489
All	Δ^b	0.1577	0.2260	1.2878	2.6339	0.9706	0.1882	0.0243	0.3787	0.1595	1.1054
Pre 1870	$-\Omega^b$	−0.4456	−0.5374	−0.4662	−0.6740	−0.6029	−0.5118	−0.5489	−0.1336	−0.2663	−0.5307
Pre 1870	$-\Omega^w$	−2.0635	−3.1100	−9.7347	−13.585	−4.1337	−3.1384	−0.6621	−1.9809	−1.3987	−9.6972
Pre 1870	Δ^w	3.0200	4.4401	12.916	18.640	5.2825	4.5664	0.7543	2.4292	1.7084	13.026
Pre 1870	Δ^b	1.8008	2.6942	2.5809	5.7564	2.5380	2.2240	1.3373	0.1794	0.5671	3.3853
1870–1890	$-\Omega^b$	−0.2537	−0.3986	−0.6943	−0.8528	−0.7680	−0.7247	−0.4693	−0.5624	−0.4282	−0.7301
1870–1890	$-\Omega^w$	−0.6921	−0.9072	−7.2846	−10.570	−4.1230	−2.0352	−0.8885	−1.5718	−0.8343	−7.1136
1870–1890	Δ^w	0.8554	0.9754	8.1326	12.085	4.7211	2.4898	1.0612	1.7112	0.8843	8.0426
1870–1890	Δ^b	0.6030	0.9838	4.4218	6.7543	3.9221	2.9706	1.3548	1.4702	0.9442	4.7035
1900–1950	$-\Omega^b$	−0.1799	−0.3476	−0.5008	−0.6534	−0.4696	−0.3590	−0.0196	−0.4218	−0.3480	−0.4960
1900–1950	$-\Omega^w$	−0.1372	−0.3336	−2.0245	−3.4764	−1.4126	−0.8357	−0.0221	−0.6144	−0.3574	−1.9079
1900–1950	Δ^w	0.1442	0.3557	2.1632	3.7574	1.5390	1.0622	0.0585	0.6792	0.3854	2.0559
1900–1950	Δ^b	0.2858	0.5806	1.7920	2.8114	1.4235	1.1450	0.0953	0.8637	0.5981	1.7153
Pre 1960	$-\Omega^b$	−0.2298	−0.3681	−0.5321	−0.6999	−0.5351	−0.3913	−0.0365	−0.4187	−0.3532	−0.5443
Pre 1960	$-\Omega^w$	−0.5020	−0.6196	−4.5615	−6.6540	−2.1319	−0.9426	−0.0523	−0.9659	−0.4324	−4.0102
Pre 1960	Δ^w	0.6712	0.7576	5.4326	7.9779	2.4287	1.1899	0.0931	1.0891	0.4706	4.7685
Pre 1960	Δ^b	0.5547	0.7954	2.4631	4.1431	1.9716	1.3061	0.1410	0.9128	0.6297	2.5114
1960–2000	$-\Omega^b$	−0.0299	−0.0426	0.0195	0.0149	0.0132	−0.0156	−0.0126	−0.0139	−0.0338	−0.0056
1960–2000	$-\Omega^w$	−0.0103	−0.0174	0.3260	0.4621	0.1988	0.0569	0.0007	0.0091	−0.0153	0.1682
1960–2000	Δ^w	0.0107	0.0180	−0.3038	−0.4256	−0.1851	−0.0508	−0.0001	−0.0084	0.0158	−0.1555
1960–2000	Δ^b	0.0327	0.0491	−0.0184	−0.0097	−0.0127	0.0204	0.0138	0.0164	0.0381	0.0086

Table reports our estimates of the welfare cost of discrimination in the cost of schooling, as well as the value of Civil Rights. All values are weighted by black population.

investigate further, we plot in Figure 10 the time series of (κ^b, κ^w) for each census division as well as the US as a whole from 1800–2000. During the Jim Crow era, black schooling costs rise from 0.6 in 1900 to 1.5 in 1950, compared with a rise among whites from 0.7 to 1.3. What, then, accounts for the decline in Δ_t^b during the period? Average black young adult mortality risk declined to 23%, reducing the precautionary demand for children, and thus freeing up resources for better educating the children of those now-smaller families. It seems likely that the reduced precautionary demand for children is the source of much of the relative gains of blacks during this era.

Taken at face value, the estimated values of Δ_t^b for the Civil Rights era suggest that blacks achieved schooling parity with whites in the sense that the estimated values of Δ_t^b are different from zero only in the second decimal place. There are, however, a number of caveats. First, this exercise focuses on the quantity of schooling and not its quality. If the cost of school quality for blacks fell more slowly than the cost of school quantity, and blacks substituted school quantity for school quality, we would exaggerate the decline in κ_t^b and hence understate Δ_t^b. Second, Canaday and Tamura (2009) note that tax revenues paid by blacks could have been diverted to pay for the schooling of whites. Third, the model does not permit labor market discrimination, such as the monopsonization of black employment modeled by Canaday and Tamura (2009).[32]

Table 9 also presents the other three welfare measures. The broad pattern with these are similar with Δ_t^b. One difference is that the white measures of welfare costs show a decline during Reconstruction as compared with slavery. All four measures show a decline in the welfare cost of education discrimination during Jim Crow compared with Reconstruction.[33]

4.1. Comparisons with Mincerian Returns

Because Mincerian returns are on the order of 10% per year of schooling, our estimates of the welfare cost of schooling inefficiency are several orders of magnitude larger. The reason for the discrepancy is that Mincerian returns measure solely the marginal, market return to a year of schooling, whereas in our model schooling is an input into the production of the next generation's human capital as well as a market return. Higher schooling costs today reduce the acquisition of schooling of children today, which reduces the ability of those children to teach their children.[34] Consider, then, the second additive term in (12), and focus only on the utility gain from human capital accumulation of children. The relative utility gain between no discrimination and the historical level of discrimination to a black parent in state s in year t, measured in units of parental wealth, is

$$\left(\frac{\bar{h}_t}{h_{st}}\right)^{\rho_{\kappa^w}-\rho_{\kappa^b}}\left(\frac{\tau_{\kappa^w}}{\tau_{\kappa^b}}\right)^{\mu}. \tag{23}$$

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The first term captures the feature that as schooling increases, the ability to take advantage of the spillover human capital rises.[35] The second term is the direct effect from rising schooling levels.[36]

The gains from increased schooling are contained in Table 10, which shows blacks in the top panel and whites in the bottom. Within each panel, we examine the same time periods and divisions, but present the three measures of gains. The first, $(\frac{\tau_\kappa^b}{\tau^b})^\mu = T^b$, measures the increased human capital from increased schooling. The second, $(\frac{\overline{h}}{h^b})^{\rho_\kappa - \rho} = H^b$, measures the increased human capital from increased utilization of the spillover human capital, $\overline{h}$. The third measures the net percent gain in human capital, $T^b * H^b - 1$. The average gain for blacks prior to the Civil War was almost 800%. This ranged from as small as 30% in the West North Central division, to a high of almost 1300% in the East South Central division. The other two southern divisions each had human capital gains of over 600%. Outside of the south all divisions had gains essentially less than 400%.

During Reconstruction, human capital gains for blacks rise from 800% to 950%, largely due to the increased value of utilizing the spillover human capital. Staying in school longer and increasing the ability to tap into the spillover, rising ρ, causes an increase in human capital by about 875%. In fact the direct gain from longer schooling falls from 60% prior to the Civil War to less than 20% during Reconstruction. However, there is a reduction in human capital gains in three divisions: New England, Middle Atlantic, and the Pacific. These are precisely the divisions with lower welfare cost measures of discrimination measured by CV^b, and two of the three divisions, Pacific being the lone exception, measured by EV^b.

The bottom half of Table 10 shows the white human capital gains from decreased education discrimination, that is what the additional human capital white children acquire given their κ_{it}^w instead of facing κ_{it}^b. In order to express the human capital gain as a proportion of black human capital in the white panel we apply the $Z = \frac{h^w}{h^b}$ term in the third measure. During Reconstruction, the human capital gain declines from the pre Civil War value of 2300% to bit more than 1800%. Notice that the gains in increased schooling length from decreased education discrimination fall from 46% prior to the Civil War to 10% during Reconstruction. Also the gains from additional utilization of the human capital spillover increases modestly, from 6% to 12%. The large human capital gains accrue via the large gap between black and white human capital. Prior to the Civil War white parental human capital was about 40 times that of black parental human capital. In the southern three divisions it is more than 41 times larger, and outside of these three divisions it was more than 18 times larger. During Reconstruction, white parental human capital of blacks was 77 times larger than black parental human capital. White parents in the southern three divisions had more than 83 times the average black parental human capital. Outside of the southern three divisions, white parental human capital was 19 times larger than black parental human capital. Outside of

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TABLE 10. Sub-utility gains from equal Education opportunity schooling differences, no DC

Years	Variable	NE	MA	SA	ESC	WSC	MTN	PAC	WNC	ENC	US
					Black						
All	$(\tau_\kappa^b/\tau^b)^\mu = T^b$	1.033	1.026	1.098	1.135	1.070	1.010	1.004	1.034	1.017	1.074
All	$(\bar{h}/h^b)^{\rho_\kappa-\rho} = H^b$	1.146	1.192	3.052	4.328	2.514	1.134	1.021	1.482	1.156	2.567
All	$T^b * H^b - 1$	0.228	0.251	2.627	4.367	1.873	0.164	0.028	0.565	0.183	2.012
Pre 1870	T^b	1.508	1.457	1.567	1.765	1.557	1.785	1.278	1.193	1.238	1.605
Pre 1870	H^b	2.427	3.040	4.665	8.147	4.742	2.760	2.937	1.080	1.985	5.457
Pre 1870	$T^b * H^b - 1$	3.051	3.753	6.484	12.87	6.114	4.032	2.701	0.298	1.589	7.910
1870–1890	T^b	1.076	1.079	1.176	1.185	1.220	1.262	1.142	1.120	1.090	1.179
1870–1890	H^b	1.829	2.188	8.964	10.96	7.657	4.350	2.580	4.057	2.620	8.742
1870–1890	$T^b * H^b - 1$	1.103	1.380	9.728	12.13	8.376	4.697	2.059	3.592	1.870	9.479
1900–1950	T^b	1.035	1.044	1.067	1.077	1.074	1.037	1.007	1.046	1.041	1.065
1900–1950	H^b	1.292	1.474	3.652	4.073	3.081	1.701	1.075	1.731	1.471	3.200
1900–1950	$T^b * H^b - 1$	0.342	0.544	2.977	3.446	2.372	0.799	0.091	0.820	0.535	2.477
Pre 1960	T^b	1.110	1.082	1.186	1.212	1.140	1.058	1.013	1.078	1.051	1.165
Pre 1960	H^b	1.538	1.668	4.894	6.225	4.054	1.934	1.132	2.141	1.593	4.553
Pre 1960	$T^b * H^b - 1$	0.852	0.889	4.988	6.856	3.777	1.143	0.166	1.336	0.691	4.565
1960–2000	T^b	1.008	1.009	1.000	1.001	1.001	1.003	1.003	1.005	1.009	1.004
1960–2000	H^b	1.023	1.044	1.004	1.006	1.002	1.014	1.011	1.035	1.043	1.019
1960–2000	$T^b * H^b - 1$	0.032	0.053	0.004	0.007	0.003	0.017	0.015	0.041	0.052	0.023

Table 10. Conitnued

Years	Variable	NE	MA	SA	ESC	WSC	MTN	PAC	WNC	ENC	US
					White						
All	$(\tau^w/\tau_\kappa^w)^\mu = T^w$	1.029	1.029	1.068	1.102	1.044	1.026	1.009	1.047	1.027	1.057
All	$(\bar{h}/h^w)^{\rho-\rho_\kappa} = H^w$	1.001	1.007	1.043	1.068	1.044	1.015	1.002	1.047	1.016	1.038
All	$Z[T^w * H^w - 1]$	0.255	0.285	6.366	11.27	2.723	0.443	0.048	1.072	0.250	4.642
Pre 1870	T^w	1.367	1.358	1.450	1.571	1.348	1.755	1.144	1.183	1.166	1.461
Pre 1870	H^w	1.000	1.010	1.063	1.070	1.051	1.082	1.059	1.021	1.019	1.060
Pre 1870	$Z[T^w * H^w - 1]$	4.315	5.914	23.01	33.27	8.978	9.295	1.275	4.057	2.649	23.09
1870–1890	T^w	1.043	1.058	1.090	1.103	1.120	1.258	1.134	1.072	1.053	1.096
1870–1890	H^w	1.005	1.023	1.129	1.131	1.136	1.122	1.092	1.108	1.049	1.124
1870–1890	$Z[T^w * H^w - 1]$	1.388	1.476	18.99	27.39	9.775	5.364	2.102	4.085	1.883	18.29
1900–1950	T^w	1.037	1.068	1.046	1.077	1.059	1.120	1.006	1.104	1.086	1.062
1900–1950	H^w	1.004	1.023	1.085	1.115	1.096	1.086	0.993	1.122	1.060	1.087
1900–1950	$Z[T^w * H^w - 1]$	0.234	0.565	6.581	10.41	4.209	3.073	0.309	1.911	0.916	5.863
Pre 1960	T^w	1.086	1.092	1.133	1.163	1.094	1.133	1.010	1.106	1.085	1.127
Pre 1960	H^w	1.004	1.022	1.090	1.111	1.100	1.090	0.996	1.107	1.058	1.090
Pre 1960	$Z[T^w * H^w - 1]$	1.004	1.099	12.22	17.80	5.618	3.279	0.370	2.602	1.057	10.68
1960–2000	T^w	1.011	1.010	0.995	0.997	0.994	1.010	1.009	1.007	1.012	1.002
1960–2000	H^w	1.000	1.003	0.992	0.992	0.990	1.003	1.003	1.005	1.006	0.997
1960–2000	$Z[T^w * H^w - 1]$	0.019	0.032	– 0.145	– 0.180	– 0.121	0.017	0.019	0.033	0.041	– 0.063

Table reports our estimates of the gains in human capital from equal education opportunity, that is assuming $\kappa_{it}^b = \kappa_{it}^w$. In the white panel of the table, the first two rows in each sub-panel are as percent of white wealth. The third row in each sub-panel is as a percent of black wealth, therefore $Z = h^w/h^b$. All values are weighted by black population.

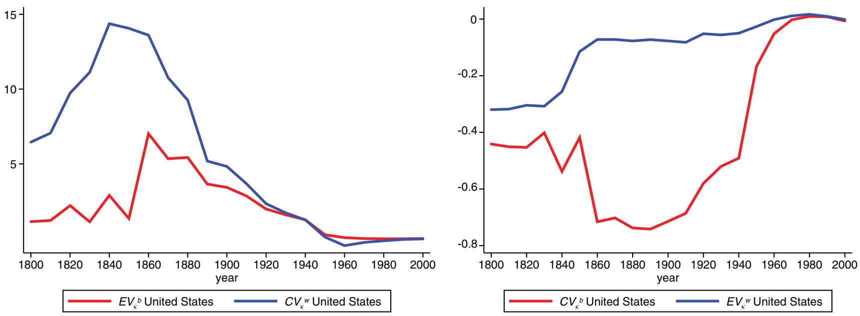

FIGURE 11. (Colour online) Left panel: EV_κ^b, CV_κ^w, right panel: CV_κ^b, EV_κ^w.

the south, there was barely any change in the ratio of white to black parental human capital. In combination with the general reduction in gains from white schooling gains, and white gain from greater spillover utilization, there is a reduction in human capital gains, as measured relative to black human capital in the northern census divisions. Four of six northern census divisions have declining welfare costs of education discrimination, and one with basically no change. Only the Pacific shows a rising welfare cost of education discrimination. Even in the south, two of three census divisions have declining welfare costs of education discrimination, with rising welfare costs only in the West South Central division. Therefore six of nine divisions have declining human capital gains, one essentially constant human capital gain, and two rising human capital gains. However these human capital gains overstate the utility gain, as falling κ would induce a substitution away from children and towards higher schooling levels. Since parents like children, lowered fertility tempers the overall utility gain from declining education discrimination.

During Jim Crow, for blacks or whites, the human capital gains are smaller than the gains that would have occurred during Reconstruction. Thus, the welfare costs of discrimination are declining. In all nine census divisions, blacks over the 1900–1950 period would have enjoyed about 250% more human capital without the education discrimination. This compares with the 950% human capital gains during Reconstruction. In every census division, whites during Jim Crow would see their own human capital gains as nearly 600% of black human capital. While large, this is much smaller than their gains equal to a bit more than 1800% of black human capital.

We present the welfare results graphically in Figure 11. The left side of Figure 11 contains the results of the analyses for the nation. We used the computed EV_κ^b and CV_κ^w for changes in κ. We averaged over the states weighting by the state black population. Both are measured as a proportion of black lifetime wealth. In the right side of Figure 11, we present the EV_κ^w, averaging over the states weighting by the state white population. We also present the CV_κ^b averaging over

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the states weighting by the state black population. Since in these cases for most of the years $\kappa_t^b > \kappa_t^w$, the EV_κ^w, and the CV_κ^b will be negative, but bounded below by -1, we expressed these as shares of their respective race human capital. Prior to 1870, whites would have been willing to give up roughly 20% of their wealth to keep their schooling costs from becoming as bad as those faced by their state counterpart blacks. During this same period, blacks would have been willing to give up roughly 70% of their wealth in order to obtain the white prices for schooling in their states.[37]

4.2. Mortality Differences and the Value of Rising Child Life Expectancy

In this section, we examine the robustness of the welfare costs of unequal education access by looking at two other welfare costs. The model can be used to compute the welfare costs of differential mortality risks, and the welfare gains from falling mortality risk. Using the same parameterization, we can compute both the equivalent and compensating variations to both blacks and whites of mortality differentials. We compute how much better off (worse off) a typical black (white) would have been if he or she faced the same mortality risk as his or her white (black) counterpart in the state. We find that the value of differential mortality risks is similar to the value of differential education access. The timing of the maximum welfare gains for whites and blacks are quite similar to those in education access for EV^b and CV^b. Maximal gains arise for blacks during Reconstruction and then fall throughout the 1900–2000 period. This is the same pattern for whites using CV^w and EV^w, a rise in the welfare costs of black mortality risk during Reconstruction with falling welfare costs from 1900–2000. This is in contrast to the time pattern from education discrimination welfare costs from above. Recall that whites had declining welfare costs from black schooling access over the entire 1820–2000 period.

Second, we use the model to compute the value of improved life expectancy over the period 1970 vs 2000, 1950 vs 2000, 1900 vs 2000, and 1850 vs 2000. In the first case, we compare our results with those in Murphy and Topel (2006). We find that improved survivor probability of the next generation produces less welfare gains than those arising from improved survivor probability of parents at older ages. Murphy and Topel (2006) estimated the value of increased longevity in the US since 1970 to be equal to about \$3.2 trillion per year, for a cumulative value of \$95 trillion.[38]

In the first exercise, we judge the robustness of our welfare cost estimates of education discrimination by examining the results arising from mortality differences. There were strong racial differences in mortality risks. This is contained in Table 11.[39] Blacks generally faced much higher mortality risk in every division of the country. Prior to the end of slavery, the typical black child had less than a 50% probability of living to 35. We produce equivalent and compensating variations for whites and blacks by counterfactually presenting them with their racial counterpart mortality risks. Figure 12 and Table 12 present the results of this experiment, for

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TABLE 11. Population weighted average young adult mortality: δ^b, δ^w

Years & Race	NE	MA	SA	ESC	WSC	MTN	PAC	WNC	ENC	US
All, black	0.0982	0.1060	0.1998	0.2192	0.1560	0.0769	0.0561	0.1599	0.0829	0.1621
All, white	0.1208	0.1266	0.0848	0.1080	0.0775	0.0722	0.0631	0.1186	0.1109	0.1026
Pre 1870, black	0.5239	0.5956	0.5180	0.4803	0.4537	0.4429	0.4859	0.5453	0.5493	0.5053
Pre 1870, white	0.3390	0.3471	0.3137	0.2980	0.3123	0.3795	0.3360	0.3409	0.3358	0.3319
1870–1890, black	0.4772	0.5446	0.4458	0.4006	0.3908	0.4449	0.4157	0.4711	0.4949	0.4286
1870–1890, white	0.2964	0.3120	0.2627	0.2447	0.2705	0.3048	0.2751	0.2836	0.2810	0.2849
1900–1950, black	0.2260	0.2383	0.2421	0.2283	0.2167	0.2638	0.1500	0.2521	0.2105	0.2308
1900–1950, white	0.1443	0.1558	0.1365	0.1364	0.1357	0.1632	0.1386	0.1601	0.1496	0.1481
Pre 1960, black	0.3073	0.2947	0.3347	0.3066	0.2680	0.2798	0.1601	0.3303	0.2470	0.3072
Pre 1960, white	0.2040	0.2053	0.1781	0.1792	0.1569	0.1776	0.1505	0.1902	0.1903	0.1877
1960–2000, black	0.0324	0.0473	0.0541	0.0663	0.0460	0.0465	0.0468	0.0442	0.0405	0.0497
1960–2000, white	0.0212	0.0297	0.0263	0.0312	0.0252	0.0268	0.0306	0.0333	0.0295	0.0285

Table reports average young adult mortality δ^i, where $i = b, w$, averages are weighted by black and white populations, respectively.

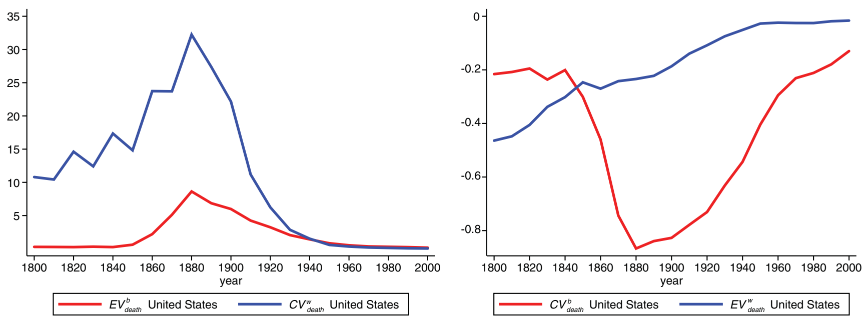

FIGURE 12. (Colour online) Left panel: EV^b_{death}, CV^w_{death}, right panel: CV^b_{death}, EV^w_{death}.

state preferences. We also find that the magnitudes of welfare costs of higher black mortality are similar to those measured for schooling access differences, which makes us confident in the size of welfare losses to blacks of differential schooling access.[40]

Table 12 contains our welfare estimates of the costs of higher young adult mortality risk. The welfare costs of differential mortality risk range from 38% (CV^b) to 150% (EV^b) to 400% (EV^w), and finally 500% (CV^w) of black lifetime wealth. The period of largest welfare costs of differential black young adult mortality is during Reconstruction, when blacks moved from rural to more urban areas within states, and to more populous states from less populous states. Prior to the end of slavery, the welfare costs for blacks range from 30% (CV^b) to 90% (EV^b) to 1200% (EV^w) and finally to 1750% (CV^w) of black lifetime wealth. These costs rise during Reconstruction to 80% (CV^b) to 700% (EV^b) to 2000% (EV^w) and finally to 2800% (CV^w) of black lifetime wealth. Computing welfare costs of differential black young adult mortality using EV^b or CV^b, we see that all census divisions had rising costs during Reconstruction compared to before the Civil War. The most pronounced increases occur in the three southern census divisions. Prior to the Civil War, these divisions had lower welfare costs (measured by CV^b and EV^b)of differential black young adult mortality than in all of the northern divisions, with the exception of the Mountain. This is a reflection of the more rural, and hence healthier location, residential pattern of southern blacks compared to more urban northern blacks. Prior to the Civil War, in these three southern divisions, the average young black adult mortality was about 50%. In comparison, the average white young adult mortality prior to the Civil War was 31%. Prior to 1870 outside of these three southern divisions, young black adult mortality was 57%, and young white adult mortality was 34%. During Reconstruction, there is a dramatic increase in the welfare cost of differential young adult mortality risk, and becomes much larger in the three southern divisions than anywhere else in the US. Black young adult mortality during Reconstruction in the three southern divisions was 42%, compared to 26%

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TABLE 12. Welfare cost of differential mortality, state preferences: Black compensating variation $-\Omega^b$, white equivalent variation $-\Omega^w$, white compensating variation Δ^w, black equivalent variation Δ^b (all as proportion of black life time wealth)

Years	Welfare	NE	MA	SA	ESC	WSC	MTN	PAC	WNC	ENC	US
All	$-\Omega^b$	−0.1509	−0.1880	−0.4792	−0.5619	−0.3940	−0.1699	−0.0813	−0.2946	−0.1713	−0.3807
All	$-\Omega^w$	−0.1551	−0.3408	−6.0144	−8.6468	−1.8610	−0.2042	−0.0436	−1.1899	−0.2368	−3.9732
All	Δ^w	0.1777	0.4587	8.1319	11.469	2.2604	0.2332	0.0463	1.6376	0.3035	5.2933
All	Δ^b	0.2799	0.3777	2.2795	2.8353	1.0954	0.2903	0.0980	1.0336	0.3275	1.5712
Pre 1870	$-\Omega^b$	−0.3689	−0.4800	−0.2955	−0.2652	−0.3196	−0.1056	−0.4908	−0.5713	−0.6232	−0.3063
Pre 1870	$-\Omega^w$	−1.9038	−6.5338	−12.980	−14.787	−4.3358	−2.3672	−1.1834	−7.1392	−6.0124	−12.119
Pre 1870	Δ^w	2.3428	10.219	18.723	21.682	5.3666	3.7460	1.5566	10.953	9.5923	17.543
Pre 1870	Δ^b	1.1596	2.3736	0.7295	0.7695	1.1438	0.1200	1.1642	3.5121	3.1138	0.9295
1870–1890	$-\Omega^b$	−0.6422	−0.7749	−0.8625	−0.8753	−0.6670	−0.4736	−0.5859	−0.8040	−0.7696	−0.8243
1870–1890	$-\Omega^w$	−1.2784	−4.3233	−23.457	−28.576	−7.0135	−1.9036	−1.2419	−6.4519	−4.3845	−20.385
1870-1890	Δ^w	1.4216	5.7409	33.023	38.822	8.9982	2.3795	1.5217	8.9872	6.0128	28.122
1870–1890	Δ^b	1.9413	3.5010	8.6198	8.2342	2.5386	1.3567	1.5640	5.0504	3.5116	7.0258
1900–1950	$-\Omega^b$	−0.3522	−0.4016	−0.7008	−0.7329	−0.5850	−0.4476	−0.1978	−0.5056	−0.4010	−0.6266
1900–1950	$-\Omega^w$	−0.2072	−0.4958	−7.0534	−7.7861	−2.6453	−1.1297	−0.1609	−1.0968	−0.4781	−5.0926
1900–1950	Δ^w	0.2193	0.5685	8.8490	9.5380	3.1207	1.3103	0.1756	1.3221	0.5507	6.2891
1900–1950	Δ^b	0.6444	0.8329	3.5008	3.5778	1.7664	1.1753	0.3032	1.3815	0.8267	2.6666
Pre 1960	$-\Omega^b$	−0.3983	−0.4398	−0.6551	−0.6877	−0.5781	−0.4497	−0.2113	−0.5748	−0.4420	−0.6164
Pre 1960	$-\Omega^w$	−0.6162	−1.3354	−11.396	−13.422	−3.5823	−1.1985	−0.1999	−2.8838	−1.0050	−8.9323
Pre 1960	Δ^w	0.7103	1.8307	15.467	17.848	4.3790	1.4059	0.2247	3.9899	1.3253	11.949
Pre 1960	Δ^b	0.9149	1.1897	3.9735	4.1290	1.8561	1.1905	0.3466	2.3809	1.1447	3.2169
1960–2000	$-\Omega^b$	−0.0731	−0.1098	−0.2892	−0.3416	−0.2133	−0.1279	−0.0696	−0.1045	−0.1013	−0.1981
1960–2000	$-\Omega^w$	−0.0099	−0.0318	−0.2025	−0.2819	−0.1702	−0.0550	−0.0295	−0.0410	−0.0385	−0.1301
1960–2000	Δ^w	0.0100	0.0324	0.2110	0.2939	0.1793	0.0572	0.0303	0.0420	0.0397	0.1356
1960–2000	Δ^b	0.0800	0.1254	0.4501	0.5691	0.3482	0.1552	0.0756	0.1198	0.1164	0.2957

Table reports our estimates of the welfare cost of differential mortality. All values are weighted by black population.

for white young adult mortality. Outside of these three southern divisions, during Reconstruction, average black young adult mortality was 50% versus average white young adult mortality of 29%. During Reconstruction for blacks in the three southern divisions, white young adult mortality risk, 26%, is similar to black young adult mortality risk in these southern divisions over the 1900–1940 period, 26%. Average black fertility in the three southern divisions during Reconstruction is 6.8, with average schooling of 2.2 years. Average black fertility in the three southern divisions during 1900–1940, is 4.4, with average schooling of 5.9 years. Thus, the welfare costs to blacks of differential mortality during Reconstruction is in the heart of their demographic transition. To match the pre Civil War southern white young adult mortality of 31%, this occurred for southern blacks over the period 1900–1910, 33%. For these southern blacks, average fertility and schooling is 5.6 children and 4.6 years, respectively. By comparison, average southern black fertility and southern black schooling during the pre Civil War period is 7.4 children and 0.12 years of schooling. Thus prior to the Civil War, we would expect welfare gains arising from a decline of 1.8 children (5.6 vs. 7.4) and an increase of 4.5 years of schooling (4.6 years vs 0.11 years). During Reconstruction, we would expect welfare gains arising from a decline of 2.4 children (4.4 vs. 6.8) and an increase of 3.7 years of schooling (5.9 vs. 2.2). However, recall that during Reconstruction the gain from rising years of schooling to take advantage of the rise in spillover human capital is the largest of all time periods, see Table 10.

In contrast to the time series of welfare costs using EV^b or CV^b, we find that using EV^w or CV^w produces rising welfare costs of differential young adult mortality only in the three southern divisions. For the other six divisions, welfare costs fall during Reconstruction compared to the pre-Civil War era. Thus, we are confident that there is a rising cost of differential young adult mortality in the three southern divisions, and more mixed results for the other six census divisions.

During the Jim Crow era, 1900–1950, the welfare costs of differential mortality falls in comparison with the Reconstruction period. This is true of the 36 division cases, nine divisions, and four welfare measures. For the US during Jim Crow, the welfare costs of differential mortality range from 62% (CV^b) to 267% (EV^b) and from 500% (EV^w) to 600% (CV^w) of black lifetime wealth. With the exception of CV^b, all other welfare measures are less than half their comparable measures during Reconstruction. For CV^b, the decline is from 82% to 62%.

Finally during the 1960-2000 period, welfare costs of differential mortality falls in comparison with the Jim Crow era. In every census division, the welfare costs decline substantially. Welfare costs decline by at least 67%, for example the smallest decline comes from CV^b. During Jim Crow, the welfare cost was equal to 62% of black lifetime wealth, but during the 1960–2000 period the welfare cost is 20% of black lifetime wealth. In the other three cases, the decline is 90% for EV^b, 97% for EV^w, and CV^w.[41]

4.3. The Value of Improved Child Life Expectancy

In this subsection, we present measures of the value of improved child longevity since 1970, 1950, 1900, and 1850. We view this exercise as another robustness check on our welfare cost estimates above. We expect that our answers will be smaller in magnitude than what is found in Murphy and Topel (2006) as the decline in young adult mortality is discounted relative to one's own mortality. However, it is conceivable that the mortality declines prior to 1970 are sufficiently large to produce welfare gains in excess of those found in Murphy and Topel (2006).

Table 13 presents the Equilibrating Value in the year 2000 of increased child longevity for blacks and whites in each of the four comparison years, 1970, 1950, 1900, and 1850.[42] For the US as a whole, we find that welfare gains for blacks greatly exceed those for whites. The EV^b produces 14% and 3% lifetime wealth gains for blacks and whites respectively from improvements in child survivability since 1970. Recall that Murphy and Topel (2006) find welfare gains from life extension, particularly for those over 40, net of increased medical expenditures of \$61 trillion, or about 125% of total wealth. Thus, our estimates are only on the order of 2% to 10% of those estimated by Murphy and Topel (2006). The value of increased child longevity since 1950, which captures the effect of the discovery of antibiotics, almost double the previous measures, 27% for blacks and 5% for whites. For whites, the range goes from a low of 1% of their wealth in Connecticut, to a high of 9.5% of their wealth in Michigan. For blacks, the range varies from 4% in South Dakota to 99% in Missouri. Since 1900 black gains are equal to 100% of their lifetime wealth, and white gains are equal to 13% of their lifetime wealth. Moving to the gains over the century, our estimates of black gains range from a low of 11% in South Dakota to a high of 360% in North Dakota.[43] For whites, the gains range from 4% in Connecticut to 24% in New Mexico. Finally, over the 1850–2000 period, the gains to blacks overall are equal to 330% of their lifetime wealth and 21% of white lifetime wealth. For blacks, the range goes from a low of 45% in New Hampshire, to a high of 1600% in Texas. For whites, the gain in child longevity ranges from 6% in Connecticut to 31% in Michigan.

While the black welfare measures seem quite plausible, with rising welfare gains, going backward in time, of 14% in 1970 to 330% in 1850, the white numbers seem too low. It seems implausibly low that it would only take 21% of lifetime wealth in 2000 to compensate for 1850 child life expectancy. Much of this is driven by the sharp decline in the preference parameter β post 1950. By 2000, the value of β averages 0.09 for whites, whereas for blacks the average is 0.64. The large discrepancy is needed in order to fit black fertility and white fertility during the Civil Rights era. There is almost no corresponding differences in ν. For whites, the average in 2000 of this taste parameter is 0.5, and for blacks the average is 0.49. As a result, there is still a large precautionary demand for fertility amongst blacks, and hence a large premium to be valued for lower mortality risk.

TABLE 13. Value of medical advances: Equilibrating values

Region	EV^b_{1970}	EV^w_{1970}	EV^b_{1950}	EV^w_{1950}	EV^b_{1900}	EV^w_{1900}	EV^b_{1850}	EV^w_{1850}
United States	14.3%	2.66%	26.9%	5.22%	98.6%	12.8%	332%	20.7%
New England	10.1	0.46	25.9	1.42	73.8	5.38	114.	8.63
Connecticut	5.03	0.32	10.7	1.08	44.9	3.95	75.7	5.81
Maine	4.72	0.35	17.0	1.22	79.9	4.62	130.	8.21
Massachusetts	14.4	0.54	41.1	1.61	104	6.43	154.	10.5
New Hampshire	0.74	0.39	4.69	1.24	31.1	4.50	45.3	7.35
Rhode Island	13.7	0.68	20.5	1.96	55.3	6.53	79.3	9.18
Vermont	13.8	0.35	23.0	1.22	62.0	4.24	160.	7.44
Middle Atlantic	12.8	1.48	25.3	4.21	100	12.9	185.	17.2
New Jersey	5.30	0.89	12.6	2.44	64.6	7.25	121.	9.99
New York	17.2	1.85	32.9	5.56	117	17.7	204.	22.4
Pennsylvania	9.03	1.38	18.6	3.56	92.9	10.4	198.	15.0
South Atlantic	7.79	2.54	18.3	4.66	82.9	10.9	316.	18.3
Delaware	10.5	1.12	19.7	2.96	88.2	8.24	176.	11.9
D.C.	8.27	0.81	16.3	2.32	58.2	5.71	83.1	6.65
Florida	3.70	2.35	11.0	4.37	46.8	10.4	126.	17.8
Georgia	5.28	2.60	16.4	4.33	67.9	8.96	194.	14.6
Maryland	4.68	0.71	12.3	2.10	76.8	6.50	168.	10.0
North Carolina	3.83	2.64	12.1	5.01	55.5	12.3	161.	21.7
South Carolina	16.4	1.85	35.4	3.85	219	10.6	1511	19.2
Virginia	19.3	4.81	33.6	7.84	100	15.7	244.	25.3
West Virginia	9.01	2.05	18.7	4.19	62.0	12.1	–	–
East South Central	7.61	2.42	16.7	4.54	54.2	10.5	136.	17.9
Alabama	8.44	2.31	17.8	4.15	49.1	9.08	101.	15.2
Kentucky	7.01	2.95	16.7	5.43	63.0	12.8	175.	21.9
Mississippi	7.92	1.83	17.2	3.09	58.4	6.95	162.	11.5
Tennessee	6.42	2.29	14.9	4.66	53.1	11.0	140.	18.9
West South Central	33.1	2.91	54.3	6.59	183	16.3	994.	28.2
Arkansas	11.9	5.74	22.1	8.45	64.0	16.6	173.	26.8
Louisiana	11.9	3.26	23.9	5.84	76.4	14.0	215.	24.7
Oklahoma	5.45	1.51	10.7	3.33	40.8	11.1	–	–
Texas	52.7	2.68	82.9	7.05	284	17.6	1607	29.1
Mountain	16.1	2.56	29.4	5.29	94.7	15.2	–	–
Arizona	15.1	3.99	27.7	7.94	104	24.6	–	–
Colorado	18.9	1.24	33.5	2.84	103	7.75	–	–
Idaho	19.6	2.72	38.4	5.43	159	16.3	–	–
Montana	18.0	0.94	29.3	1.88	70.4	5.27	–	–
Nevada	15.6	1.29	28.2	2.45	81.9	6.43	–	–
New Mexico	7.30	2.40	18.7	7.00	58.1	23.5	–	–
Utah	14.5	4.14	26.6	7.52	78.9	16.1	–	–
Wyoming	26.6	1.00	57.7	2.79	150	10.9	–	–

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TABLE 13. Continued

Region	EV^b_{1970}	EV^w_{1970}	EV^b_{1950}	EV^w_{1950}	EV^b_{1900}	EV^w_{1900}	EV^b_{1850}	EV^w_{1850}
Pacific	3.50	2.88	8.47	5.10	28.4	12.1	52.5	25.3
Alaska	4.12	0.51	–	–	–	–	–	–
California	3.07	3.67	8.05	6.42	26.7	14.6	52.5	25.3
Hawaii	9.47	0.85	–	–	–	–	–	–
Oregon	6.68	0.98	14.3	2.11	42.6	5.68	–	–
Washington	6.85	1.11	12.9	2.30	44.9	5.79	–	–
West North Central	37.2	2.77	65.0	4.94	186	12.0	689.	19.3
Iowa	1.82	1.41	10.1	2.69	41.2	6.79	75.6	12.3
Kansas	2.36	3.77	7.31	6.30	33.4	15.0	–	–
Minnesota	12.2	2.79	25.4	4.98	80.7	11.2	–	–
Missouri	58.3	3.43	99.0	5.85	269	13.3	750.	23.3
Nebraska	19.6	3.30	36.7	6.05	166	16.2	–	–
North Dakota	27.4	0.57	62.9	2.61	358	13.3	–	–
South Dakota	1.58	0.76	3.91	2.22	11.3	8.96	–	
East North Central	18.4	4.20	30.4	7.45	104	15.9	212.	24.5
Illinois	19.2	4.75	31.1	8.08	101	16.8	196.	26.0
Indiana	17.3	3.08	30.5	5.63	121	12.7	265.	20.0
Michigan	7.50	5.73	16.5	9.47	75.4	19.6	164.	31.1
Ohio	32.3	3.43	48.5	6.91	146	15.0	297.	22.0
Wisconsin	6.40	3.45	13.3	5.97	53.6	13.4	93.2	20.7

5. HUMAN CAPITAL AND OUTPUT

We have calibrated our model using data on black and white mortality, fertility, and schooling and average long run growth rate of output per worker, but without using data on output or labor market earnings. One might therefore question the validity of estimates of the welfare cost, which are based on equivalent and compensating variations in human capital estimated purely via a quantity–quality model of fertility. In this section, we empirically confront the model solutions of human capital with data on state output per worker, and measures of earnings, and permanent income by state and race. To briefly summarize our findings, the model's time series of black and white human capital is positively and strongly correlated with measures of state output per worker, black and white permanent income and black and white earnings. Furthermore, the growth rates of black and white human capital are also positively and generally statistically correlated with the growth rates of output per worker, black and white permanent income and black and white earnings.

Figures 13 and 14 present the time series of white and black human capital by division. The human capital from the model can be used to compute average human capital in state i and year t, and is equal to the weighted average of human

TABLE 14. Fixed effects regressions: $ln(y)$ top panel, g_y bottom panel; (standard error)

Variable y =	Output	Output	Output	Output	Permanent income black	Permanent income white	Earnings black	Earnings white
lnh	0.844	0.854	0.800	0.811				
	(0.015)	(0.014)	(0.014)	(0.013)				
lhh_{black}					0.293		0.340	
					(0.014)		(0.016)	
lnh_{white}						0.583		0.747
						(0.011)		(0.014)
Gold		0.785		0.729				
		(0.018)		(0.016)				
Silver		0.993		0.929				
		(0.258)	–	(0.262)				
Constant	7.214	7.179	7.384	7.342	9.188	8.078	9.069	7.441
	(0.043)	(0.039)	(0.042)	(0.038)	(0.034)	(0.045)	(0.044)	(0.057)
Imputed data	yes	yes	no	no				
N	890	890	788	788	515	551	390	404
$\overline{R}^2$	0.9279	0.9356	0.9278	0.9371	0.5501	0.6937	0.5668	0.7736

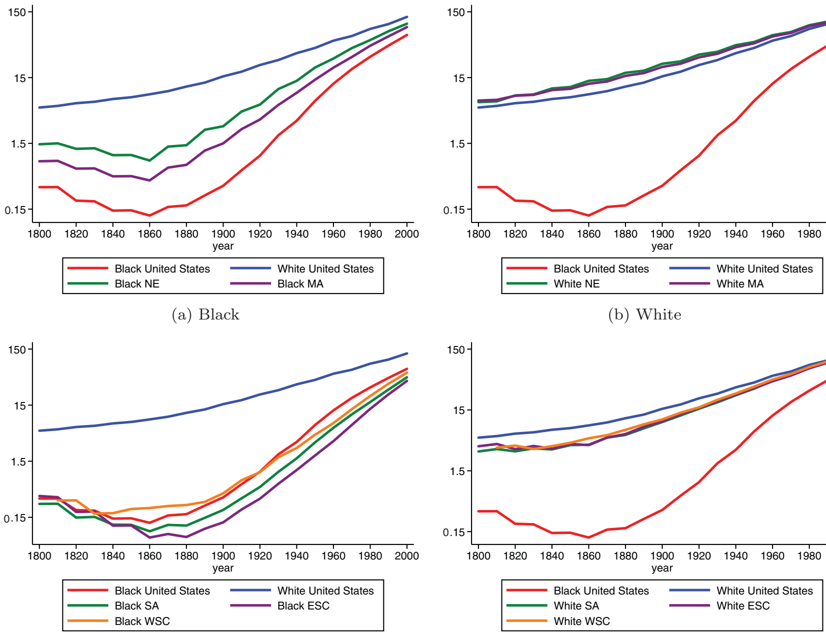
Table 14. Continued

growth rates $g_y =$	output	output	output	output	permanent income black	permanent income white	earnings black	earnings white
g_h	0.409	0.375	0.606	0.549				
	(0.093)	(0.087)	(0.118)	(0.116)				
$g_{h_{black}}$					0.423		0.261	
					(0.123)		(0.179)	
$g_{h_{white}}$						1.284		0.119
						(0.222)		(0.328)
Gold		−0.037		−0.032				
		(0.003)		(0.004)				
Silver		−0.022		−0.019				
		(0.001)		(0.002)				
Constant	0.008	0.009	0.005	0.006	−0.006	−0.017	0.005	0.014
	(0.002)	(0.001)	(0.002)	(0.002)	(0.006)	(0.005)	(0.008)	(0.007)
Imputed data	yes	yes	no	no				
N	839	839	737	737	464	500	339	353
$\overline{R}^2$	0.0615	0.0758	0.0713	0.0816	0.0409	0.1014	0.0148	0.0005

TABLE 15. Relative black human capital

Years	NE	MA	SA	ESC	WSC	MTN	PAC	WNC	ENC	US
1800	0.2159	0.1192	0.0821	0.0940	–	–	–	–	0.1316	0.0877
1810	0.2190	0.1182	0.0750	0.0823	0.0833	–	–	0.0857	0.1271	0.0809
1820	0.1438	0.0796	0.0456	0.0542	0.0772	–	–	0.0789	0.0974	0.0518
1830	0.1439	0.0784	0.0420	0.0486	0.0513	–	–	0.0599	0.0920	0.0471
1840	0.0906	0.0513	0.0316	0.0300	0.0474	–	–	0.0544	0.0660	0.0344
1850	0.0885	0.0493	0.0267	0.0253	0.0453	–	0.2121	0.0406	0.0609	0.0301
1860	0.0587	0.0359	0.0206	0.0160	0.0421	0.1094	0.1660	0.0392	0.0496	0.0240
1870	0.0914	0.0511	0.0196	0.0141	0.0385	0.1371	0.1744	0.0524	0.0555	0.0243
1880	0.0769	0.0465	0.0168	0.0112	0.0357	0.0823	0.1535	0.0604	0.0604	0.0223
1890	0.1241	0.0695	0.0180	0.0118	0.0324	0.1015	0.1819	0.0676	0.0714	0.0245
1900	0.1104	0.0717	0.0191	0.0128	0.0390	0.0634	0.1539	0.0778	0.0858	0.0275
1910	0.1706	0.1046	0.0248	0.0162	0.0524	0.1212	0.2156	0.1065	0.1056	0.0377
1920	0.1720	0.1165	0.0304	0.0202	0.0581	0.0815	0.2248	0.1254	0.1356	0.0481
1930	0.2696	0.1692	0.0446	0.0284	0.0813	0.1430	0.3531	0.1626	0.1668	0.0763
1940	0.2850	0.2032	0.0590	0.0393	0.0931	0.1362	0.3864	0.2079	0.2222	0.0984
1950	0.4070	0.2797	0.0880	0.0555	0.1231	0.2304	0.5032	0.2710	0.2818	0.1577
1960	0.4381	0.3346	0.1187	0.0771	0.1522	0.2561	0.5410	0.3313	0.3589	0.2191
1970	0.5658	0.4275	0.1715	0.1207	0.2175	0.4042	0.6517	0.4073	0.4282	0.3089
1980	0.5914	0.4994	0.2210	0.1776	0.2868	0.4333	0.6779	0.4847	0.5165	0.3727
1990	0.7123	0.6068	0.3075	0.2599	0.3869	0.5831	0.7701	0.5789	0.6016	0.4681
2000	0.7313	0.6601	0.3889	0.3465	0.4720	0.6192	0.7901	0.6494	0.6728	0.5303
2010	0.8132	0.7339	0.4982	0.4339	0.5601	0.7250	0.8540	0.7167	0.7304	0.6215
2020	0.8443	0.7965	0.6020	0.5627	0.6617	0.7737	0.8786	0.7898	0.8044	0.7016

Table reports our estimates of black parental human capital compared with white parental human capital. Averages weight by black population.



(a) Black (b) White

(c) Black (d) White

FIGURE 13. (Colour online) Cohort black and white human capital.

capital over cohort and race:

$$H_{it} = \sum_{j=1}^{2} \sum_{k=1}^{5} s_{ijkt} h_{ijkt} \tag{24}$$

$$h_{ij1t} = h_{ij,15-24,t}$$

$$h_{ij2t} = h_{ij,25-34,t}$$

$$h_{ij3t} = h_{ij,35-44,t}$$

$$h_{ij4t} = h_{ij,45-54,t}$$

$$h_{ij5t} = h_{ij,55-64,t}$$

$$1 = \sum_{j=1}^{2} \sum_{k=1}^{5} s_{ijkt}.$$

We compare H_{it} with state-level data on output per worker from Turner, Tamura, Mulholland (2013), available from 1840 through 2000.[44] State output values prior to 1840 are imputed as a function of the national growth rate of output per worker. For states that we first observe from 1840 onward, but have information on fertility,

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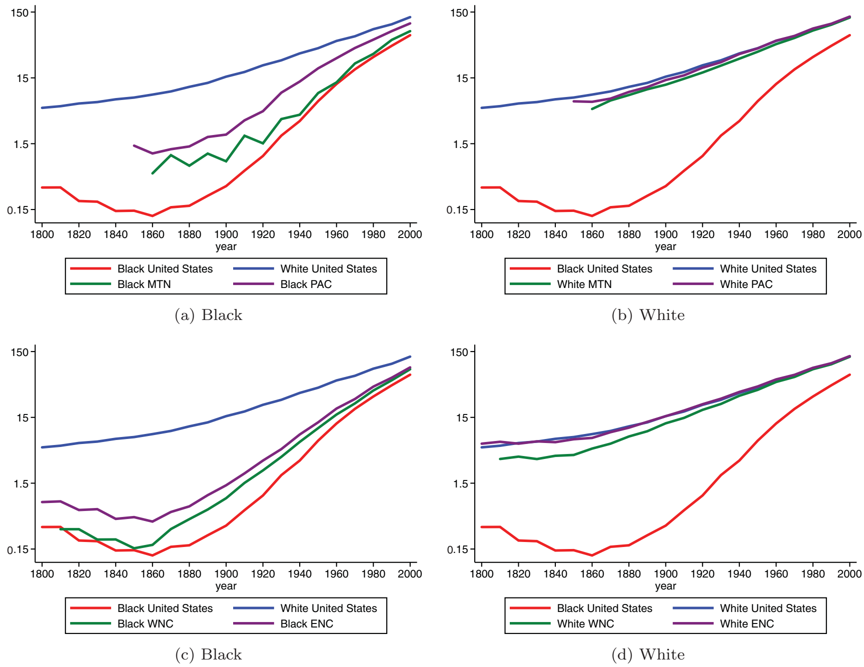

FIGURE 14. (Colour online) Cohort black and white human capital.

schooling, and population prior to their first year of observation we imputed output per worker assuming the same national growth rate as the US, and then reduced output per worker by a factor 0.98^{10} for each decade back-projected, up to a minimum of 0.98^{30}. This assumes a convergence rate similar to that typically measured in the literature of 2% per year, for example, as in Barro and Sala-i-Martin (1992) and Tamura (1996). We report our results both with and without this imputed data.

Denoting the data on output per worker as y_{it}, we estimate

$$lny_{it} = BlnH_{it} + \Gamma \text{Mining}_{it} + \mu_i + \epsilon_{it}, \quad \textbf{(25)}$$

we use fixed effects with errors clustered by state.[45] We include two dummy variables, denoted Mining_{it}, which are equal to unity for states engaged in large scale gold or silver extraction in year t, and equal to zero otherwise. Table 14 presents the regression results.[46] The regression results for the whole sample, seen in columns 1 and 2, indicate that our measures of human capital are highly correlated with state output per worker. The results in columns 3 and 4, which drop imputed data, produce nearly identical results.

Two shortcomings of state output per worker is that it may reflect factors other than human capital, and does not capture the flow of income over a lifetime. Data on labor earnings are widely available only starting with the 1940 decennial census. We therefore used census data to calculate earnings by state, census year, race, and 10-year age cohort to construct measures of “permanent income,” defined as the average annual earnings of men between the ages of 26 and 65 years.[47] Take for example natives of South Carolina who were between 16 and 25 years old in 1930. These individuals will be between the ages of 26 and 35 years in 1940, 36 and 45 in 1950, 46 and 55 in 1960, and 56–65 in 1970. Our synthetic cohort permanent income is defined as the mean earnings, in constant 2009 dollars, over these four age groups (26–65 years), weighted by cell size. We produce estimates of permanent income for whites and blacks, focusing on those born in state i and residing in state i. Ignoring the state identifier we used the following:

$$y^{pR}_{1910} = \overline{y}^{R}_{56-65,1940} \tag{26}$$

$$y^{pR}_{1920} = \frac{\overline{y}^{R}_{46-55,1940} n^{R}_{46-55,1940} + \overline{y}^{R}_{56-65,1950} n^{R}_{56-65,1950}}{n^{R}_{46-55,1940} + n^{R}_{56-65,1950}} \tag{27}$$

$$y^{pR}_{1930} = \frac{\overline{y}^{R}_{36-45,1940} n^{R}_{36-45,1940} + \overline{y}^{R}_{46-55,1950} n^{R}_{46-55,1950} + \overline{y}^{pR}_{56-65,1960} n^{R}_{56-65,1960}}{n^{R}_{36-45,1940} + n^{R}_{46-55,1950} + n^{R}_{56-65,1960}} \tag{28}$$

$$y^{pR}_{t} = \frac{\overline{y}^{R}_{26-35,t} n^{R}_{26-35,t} + \overline{y}^{R}_{36-45,t+10} n^{R}_{36-45,t+10} + \overline{y}^{R}_{46-55,t+20} n^{R}_{46-55,t+20} + \overline{y}^{R}_{56-65,t+30} n^{R}_{56-65,t+30}}{n^{R}_{26-35,t} + n^{R}_{36-45,t+10} + n^{R}_{46-55,t+20} + n^{R}_{56-65,t+30}}. \tag{29}$$

$$t = 1940, 1950, 1960, 1970, 1980 \tag{30}$$

$$y^{pR}_{1990} = \frac{\overline{y}^{R}_{26-35,1990} n^{R}_{26-35,1990} + \overline{y}^{R}_{36-45,2000} n^{R}_{36-45,2000} + \overline{y}^{R}_{46-55,2010} n^{R}_{46-55,2010}}{n^{R}_{26-35,1990} + n^{R}_{36-45,2000} + n^{R}_{46-55,2010}} \tag{31}$$

$$y^{pR}_{2000} = \frac{\overline{y}^{R}_{26-35,2000} n^{R}_{26-35,2000} + \overline{y}^{R}_{36-45,2010} n^{R}_{36-45,2010}}{n^{R}_{26-35,2000} + n^{R}_{36-45,2010}} \tag{32}$$

$$y^{pR}_{2010} = \overline{y}^{R}_{26-35,2010}, \tag{33}$$

where y^{pR}_{t} is the permanent income of 26–35 year old male cohort in census year t for race R, $\overline{y}^{R}_{X,t}$ is the average income of cohort of age X, in year t for race R, and $n^{R}_{X,t}$ is the number of individuals of cohort age X in year t of race R.[48] We regress our the log of the human capital of the young adult cohort, 25–34, born in state i and residing in state i in year t, $lnh^{R}_{25-34,i,t}$ against lny^{pR}_{it} from above:

$$lny^{pR}_{it} = Blnh^{R}_{25-34,i,t} + \mu_i + \epsilon_{it}. \tag{34}$$

Columns 5 and 6 of Table 14 presents the results of these fixed effects regressions (with errors clustered at the state level), by race, of permanent income on lnh^{R}_{it}. In

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TABLE 16. $\overline{R}^2$ of $ln(1 - p_{X+5})$ on $ln(1 - p_X)$

Variable	Avg $\overline{R}^2$	Std Dev	Minimum	Maximum
$ln(1 - p_5)$	0.9962	0.0023	0.9892	0.9995
$ln(1 - p_{10})$	0.9999	0.0001	0.9996	1.0000
$ln(1 - p_{15})$	0.9999	0.0001	0.9996	1.0000
$ln(1 - p_{20})$	0.9994	0.0004	0.9980	0.9999
$ln(1 - p_{25})$	0.9993	0.0006	0.9974	0.9998
$ln(1 - p_{30})$	0.9997	0.0002	0.9988	0.9999
$ln(1 - p_{35})$	0.9997	0.0002	0.9990	0.9999
$ln(1 - p_{40})$	0.9995	0.0003	0.9980	0.9998
$ln(1 - p_{45})$	0.9989	0.0004	0.9974	0.9997
$ln(1 - p_{50})$	0.9976	0.0007	0.9957	0.9989
$ln(1 - p_{55})$	0.9961	0.0009	0.9933	0.9979
$ln(1 - p_{60})$	0.9961	0.0010	0.9938	0.9986
$ln(1 - p_{65})$	0.9952	0.0014	0.9926	0.9978
$ln(1 - p_{70})$	0.9969	0.0011	0.9946	0.9992
$ln(1 - p_{75})$	0.9977	0.0011	0.9956	0.9995

TABLE 17. $\overline{R}^2$ of $ln(1 - p_X^{white})$ on $ln(1 - p_X)$

Variable	Avg $\overline{R}^2$	Std Dev	Minimum	Maximum
$ln(1 - p_1^w)$	0.9991	0.0016	0.9905	1.0000
$ln(1 - p_5^w)$	0.9991	0.0014	0.9930	1.0000
$ln(1 - p_{10}^w)$	0.9992	0.0013	0.9927	1.0000
$ln(1 - p_{15}^w)$	0.9992	0.0013	0.9924	1.0000
$ln(1 - p_{20}^w)$	0.9994	0.0011	0.9935	1.0000
$ln(1 - p_{25}^w)$	0.9993	0.0010	0.9943	1.0000
$ln(1 - p_{30}^w)$	0.9993	0.0010	0.9951	1.0000
$ln(1 - p_{35}^w)$	0.9991	0.0011	0.9952	1.0000
$ln(1 - p_{40}^w)$	0.9990	0.0013	0.9943	1.0000
$ln(1 - p_{45}^w)$	0.9988	0.0016	0.9926	1.0000
$ln(1 - p_{50}^w)$	0.9987	0.0019	0.9920	1.0000
$ln(1 - p_{55}^w)$	0.9982	0.0026	0.9905	1.0000
$ln(1 - p_{60}^w)$	0.9984	0.0023	0.9921	1.0000
$ln(1 - p_{65}^w)$	0.9985	0.0024	0.9909	1.0000
$ln(1 - p_{70}^w)$	0.9989	0.0018	0.9920	1.0000
$ln(1 - p_{75}^w)$	0.9992	0.0016	0.9912	1.0000

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TABLE 18. $\overline{R}^2$ of $ln(1-p_X^{black})$ on $ln(1-p_X)$

Variable	Avg $\overline{R}^2$	Std Dev	Minimum	Maximum
$ln(1-p_1^b)$	0.9368	0.1080	0.5218	0.9997
$ln(1-p_5^b)$	0.9887	0.0339	0.8295	0.9999
$ln(1-p_{10}^b)$	0.9483	0.1027	0.5299	1.0000
$ln(1-p_{15}^b)$	0.9501	0.1024	0.5217	0.9996
$ln(1-p_{20}^b)$	0.9563	0.0947	0.5422	0.9998
$ln(1-p_{25}^b)$	0.9606	0.0876	0.5624	0.9999
$ln(1-p_{30}^b)$	0.9651	0.0771	0.6001	1.0000
$ln(1-p_{35}^b)$	0.9680	0.0673	0.6424	0.9997
$ln(1-p_{40}^b)$	0.9669	0.0668	0.6633	1.0000
$ln(1-p_{45}^b)$	0.9636	0.0732	0.6794	0.9996
$ln(1-p_{50}^b)$	0.9668	0.0654	0.7049	0.9997
$ln(1-p_{55}^b)$	0.9689	0.0587	0.7257	0.9995
$ln(1-p_{60}^b)$	0.9721	0.0498	0.7631	1.0000
$ln(1-p_{65}^b)$	0.9722	0.0430	0.7886	0.9992
$ln(1-p_{70}^b)$	0.9734	0.0394	0.8062	0.9991
$ln(1-p_{75}^b)$	0.9711	0.0431	0.8168	0.9995

both specifications, the coefficient on log human capital is positive and significant at better than 1%.[49]

Finally, we construct measures of real income by race, by state. We average across all age groups within state i, those men born in state i. Thus, we construct for $1940 \leq t \leq 2010$:

$$y_t^R = \frac{\overline{y}_{26-35,t}^R n_{26-35,t}^R + \overline{y}_{36-45,t}^R n_{36-45,t}^R + \overline{y}_{46-55,t}^R n_{46-55,t}^R + \overline{y}_{56-65,t}^R n_{56-65,t}^R}{n_{26-35,t}^R + n_{36-45,t}^R + n_{46-55,t}^R + n_{56-65,t}^R} \quad \textbf{(35)}$$

$$H_t^R = \frac{h_{26-35,t}^R n_{26-35,t}^R + h_{36-45,t}^R n_{36-45,t}^R + h_{46-55,t}^R n_{46-55,t}^R + h_{56-65,t}^R n_{56-65,t}^R}{n_{26-35,t}^R + n_{36-45,t}^R + n_{46-55,t}^R + n_{56-65,t}^R}. \quad \textbf{(36)}$$

We regress the log of our measure of average human capital against the log of our average real income:

$$lny_{it}^R = BlnH_{i,t}^R + \mu_i + \epsilon_{it}. \quad \textbf{(37)}$$

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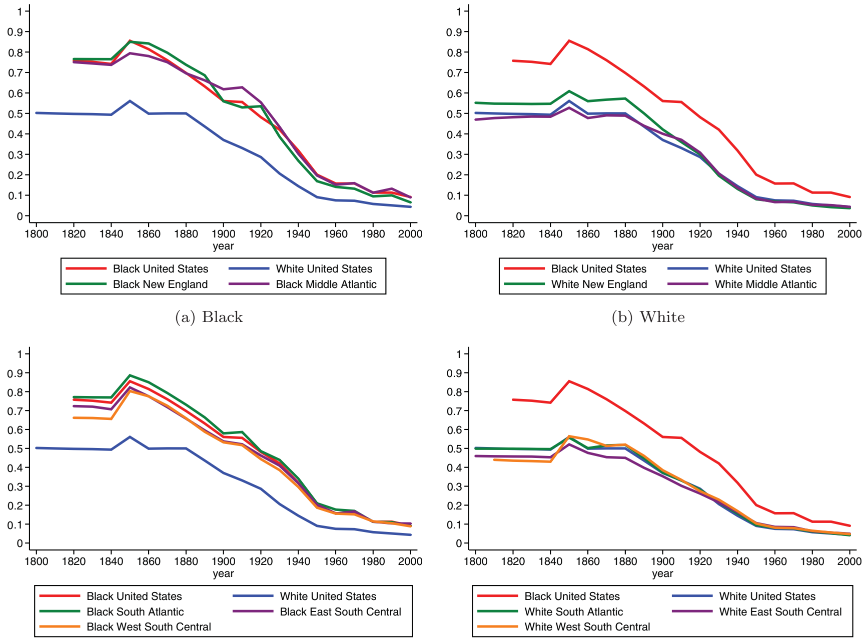

(a) Black (b) White

(c) Black (d) White

FIGURE 15. (Colour online) Cohort black and white mortality before 45.

Columns 7 and 8 of Table 14 shows the results of these fixed effects regression (with errors clustered at the state level). The results reinforce the conclusions based on permanent income.

The bottom panel of Table 14 contain regression results based on the growth rates of output per worker and the growth rates of human capital from the model.[50] The first two columns of Table 14 uses all of the data on output per worker, while columns 3 and 4 use the non imputed output per worker data. In all of these regressions, output per worker growth is strongly positively and significantly related to human capital growth. The final four columns present the results from growth rates of permanent income by race, and growth rates of earnings by race. For permanent income growth, we find positive and significant results.[51] The growth rate of earnings is positively but insignificantly related to our measures of state human capital growth rates.

6. CONCLUSION

This paper used a quantity–quality model of fertility, calibrated to data for the states of the US, by race, between 1800 and 2000, to examine the value of improved schooling access for whites and blacks. We estimate that prior to the Civil War,

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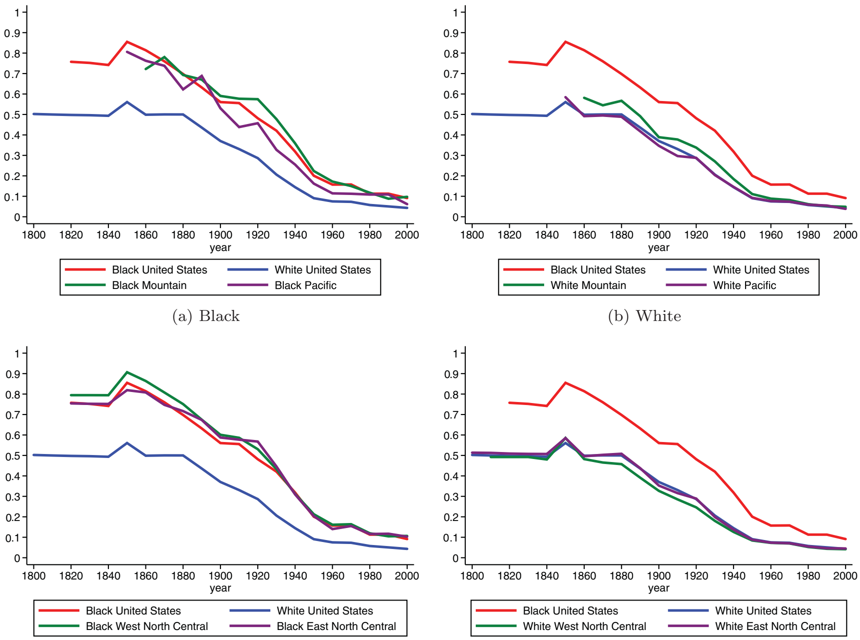

(a) Black (b) White

(c) Black (d) White

FIGURE 16. (Colour online) Cohort black and white mortality before 45.

the welfare cost of discrimination in school access ranged between 50% and 13 times black wealth, depending on division and welfare measure. Prior to 1960, we estimate the welfare cost of discrimination in the south ranges between 50% to 8 times black wealth. Interestingly, the value of schooling gains that occurred during the civil rights era was relatively modest, at just 1% of black wealth for CV^b and EV^b.[52] Outside of the South, we find significant costs of discrimination prior to 1960, ranging from 4% to 100% of black wealth. For these divisions from 1960–2000, blacks have attained rough parity in the quantity of schooling. Analysis of the value of access to quality schooling remains an important topic for research. Our measures are consistent with gains from health. Falling mortality and the closing of black and white mortality differences produce similar welfare gains. Finally, our human capital measures are strongly, positively, and significantly correlated with observed measures of output per worker, permanent income, and earnings. The growth rates of human capital from our model are strongly, positively, and significantly related to the growth rates of state output per worker, black and white permanent income. Thus, we find that the state black and white human capital time series produced by the model is empirically plausible.

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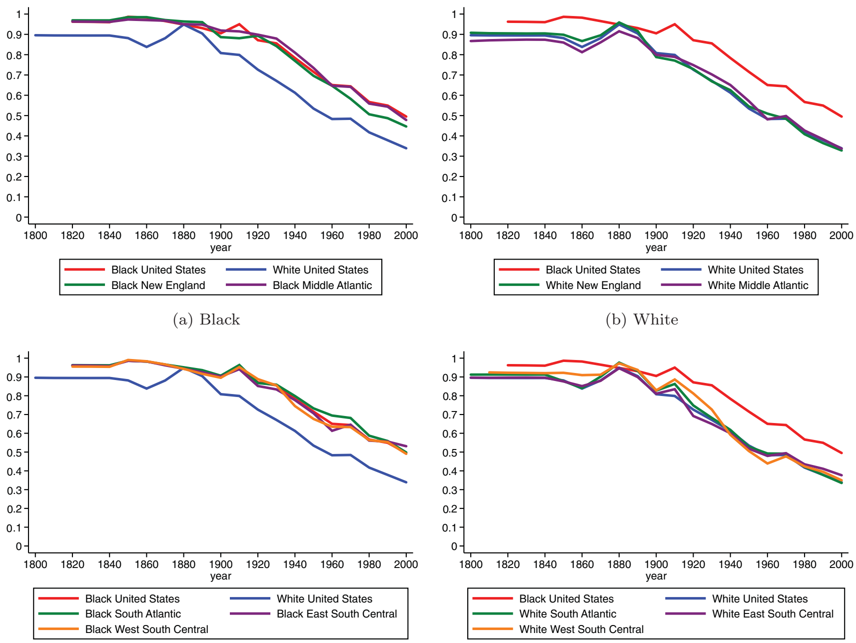

(a) Black (b) White

(c) Black (d) White

FIGURE 17. (Colour online) Cohort black and white mortality before 75.

7 APPENDIX

7.1. Imputation of Mortality Rates

For some states even after becoming a "death registration state," there are missing values. For these years, we initially seed those observations with interpolated values. We describe the estimates below. We construct log infant survival probability for each state with death registration data:

$$\text{log infant survival for state } i \text{ in year t} = ln(1 - p_{i0t}), \tag{38}$$

where p_{i0t} is the infant mortality rate in state i in year t. Based on the information without interpolated values, we run state specific regressions of log infant survival on time and time squared. We use the results of this regression to back forecast missing values of log infant survival, and finally missing infant mortality:

$$ln(1 - p_{i0t}) = \alpha_i + \beta_i t + \gamma_i t^2 \tag{39}$$

$$\hat{z}_{i0t} = \hat{\alpha}_i + \hat{\beta}_i t + \hat{\gamma}_i t^2 \tag{40}$$

$$\hat{p}_{i0t} = \min\{0.375, 1 - \exp(\hat{z}_{i0t})\}. \tag{41}$$

In (41), we place an upper bound on the infant mortality rate, 0.375, in order to keep the following methodology determining cumulative death probabilities non decreasing.[53] The

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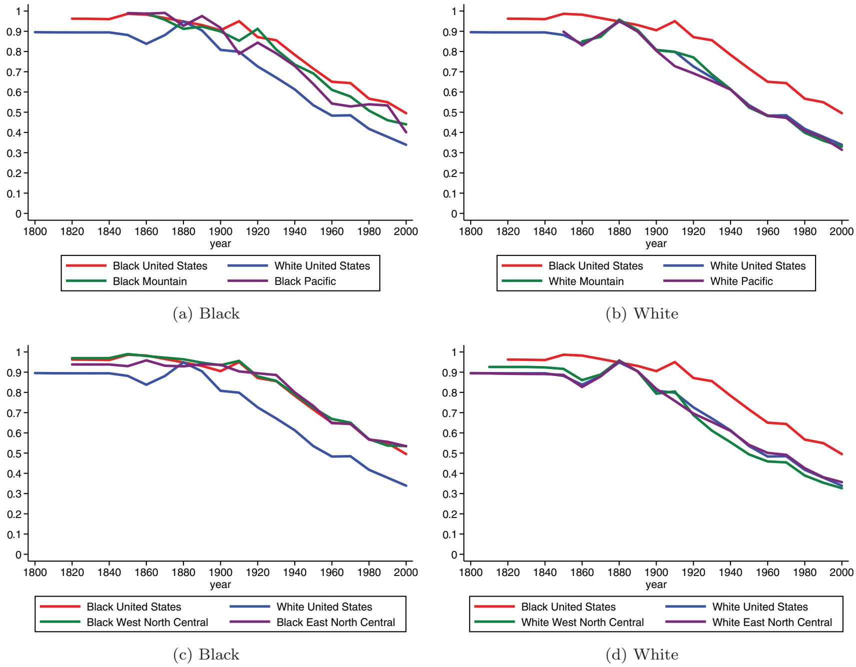

FIGURE 18. (Colour online) Cohort black and white mortality before 75.

typical time series regression has an $\overline{R}^2$ of 0.9609. The standard deviation of the $\overline{R}^2$ is 0.04. Only Pennsylvania has an $\overline{R}^2$ less than 0.90, and it is 0.7095.[54]

Next, we produce an estimate for missing probability of dying before age 5 years:

$$ln(1 - p_{i5t}) = \Lambda_{i0} ln(1 - p_{i0t}) \tag{42}$$

$$\hat{z}_{i5t} = \hat{\Lambda}_{i0} ln(1 - \hat{p}_{i0t}) \tag{43}$$

$$\hat{p}_{i5t} = \max\{1.01\hat{p}_{i0t}, \min[.45, 1 - \exp(\hat{z}_{i5t})]\}. \tag{44}$$

Equation (44) guarantees that the probability of dying before 5 is never less than the infant mortality rate, and is capped at 0.45. We continue in this manner regressing log survival to age X against log survival to age X–5, without a constant; these are presented in equations (45)–(49). We then use this regression to back forecast the missing values of log survival to age $X \geq 5$, before finally producing an estimate for the missing probability of dying before age $X \geq 5$:

$$ln(1 - p_{iXt}) = \Lambda_{iX} ln(1 - p_{iX-5t}) \tag{45}$$

$$\hat{z}_{iXt} = \hat{\Lambda}_{iX} ln(1 - \hat{p}_{iX-5t}) \tag{46}$$

$$\hat{p}_{iXt} = \max\{\Omega_X \hat{p}_{iX-5t}, \min[\omega_X, 1 - \exp(\hat{z}_{iXt})]\} \tag{47}$$

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TABLE 19. Black and white infant mortality

Year	Census Weight		Data		Haines estimate	
	White α	Black β	White	Black	White	Black
1800			260.6	–		
1810			256.2	–		
1820			251.9	280.0		
1830			248.8	274.8		
1840			244.5	266.7		
1850	0.387	0.053	216.8	340.0	216.8	340.0
1860	0.464	0.078	181.3	316.1	181.3	–
1870	0.280	0.113	175.6	277.5	175.5	–
1880	0.000	0.164	190.4	235.0	214.8	–
1890	0.134	0.238	150.6	190.3	150.6	–
1900	0.462	0.346	123.7	172.3	119.8	170.3
1910			117.7	172.8	96.5	142.6
1920			92.0	141.8	82.1	135.6
1930			65.3	111.7	60.1	99.5
1940			49.4	88.2	43.2	72.9
1950			26.8	49.0	26.8	43.9

$$\Omega_X = \begin{cases} 1.01, & \text{if } X \in \{5, 10, 15, 20, 25\} \\ 1.001, & \text{if } X \in \{30, 35, 40, 45, 50, 55\} \\ 1.0001, & \text{if } X \in \{60, 65\} \\ 1.00001, & \text{if } X \in \{70, 75\} \end{cases} \tag{48}$$

$$\omega_X = \begin{cases} 0.450, & \text{if } X = 5 \\ 0.525, & \text{if } X = 10 \\ 0.575, & \text{if } X = 15 \\ 1.00, & \text{if } X > 15 \end{cases} \tag{49}$$

We use (47)–(49) to ensure that mortality rates are non decreasing in age. We report the goodness of fit of these regressions in Table 16. As can be seen the fit of these regressions is quite good. The average $\overline{R}^2$ is better than 0.998. We are confident that this procedure produces good estimates of the state log survival probabilities. Having produced estimates of the state log survival probability for infants (age 0 years) and every 5 year age category all the way to age 75 years, we then regress log survival of whites and log survival of blacks to age X against the state log survival to age X for the years in which the state is a death registration state.

$$ln(1 - p^b_{iXt}) = \Lambda^b_{iX} ln(1 - p_{iXt}) \tag{50}$$

$$\hat{z}^b_{iXt} = \hat{\Lambda}^b_{iX} ln(1 - \hat{p}_{iXt}) \tag{51}$$

TABLE 20. Black and white fertility

	Our data		Haines		% Deviation	
Year	White	Black	White	Black	White	Black
1800	7.83	–	7.04	–	11.2	–
1810	7.72	–	6.92	–	11.6	–
1820	7.31	6.84	6.73	–	8.6	–
1830	6.67	7.67	6.55	–	1.8	–
1840	6.30	7.10	6.14	–	2.6	–
1850	5.29	7.88	5.42	7.90	– 2.4	– 0.3
1860	5.18	7.12	5.21	7.58	– 0.6	– 6.1
1870	4.76	6.74	4.55	7.69	4.6	– 12.4
1880	4.47	6.53	4.24	7.26	5.4	– 10.1
1890	4.72	6.63	3.87	6.56	22.0	1.1
1900	4.25	6.00	3.56	5.61	19.4	7.0
1910	3.54	4.81	3.42	4.61	3.5	4.3
1920	3.12	4.08	3.17	3.64	– 1.6	12.1
1930	2.78	3.31	2.45	2.98	13.5	11.1
1940	2.33	2.79	2.23	2.87	4.5	– 2.8
1950	2.09	2.48	2.98	3.93	– 29.9	– 36.9
1960	2.44	2.95	3.53	4.54	– 30.9	– 35.0
1970	2.90	3.55	2.39	3.10	21.3	14.5
1980	2.55	3.22	1.77	2.18	44.1	47.7
1990	1.88	2.26	2.00	2.48	– 6.0	– 8.9
2000	2.01	2.20	2.11	2.19	– 4.7	0.5
1890–2000 average % deviation					4.6	1.2
pre 1890 average % deviation					4.8	– 7.2

$$\hat{p}^{b}_{iXt} = \min\{\Omega_X \hat{p}^{b}_{iX-5t}, \min[\omega_X, 1 - \exp(\hat{z}^{b}_{iXt})]\} \quad \textbf{(52)}$$

$$ln(1 - p^{w}_{iXt}) = \Lambda^{w}_{iX} ln(1 - p_{iXt}) \quad \textbf{(53)}$$

$$\hat{z}^{w}_{iXt} = \hat{\Lambda}^{w}_{iX} ln(1 - \hat{p}_{iXt}) \quad \textbf{(54)}$$

$$\hat{p}^{w}_{iXt} = \max\{\Omega_X \hat{p}^{w}_{iX-5t}, \min[\omega_X, 1 - \exp(\hat{z}^{w}_{iXt})]\} \quad \textbf{(55)}$$

$$\Omega_X = \begin{cases} 1.01, & \text{if } X \in \{5, 10, 15, 20, 25\} \\ 1.001, & \text{if } X \in \{30, 35, 40, 45, 50, 55\} \\ 1.0001, & \text{if } X \in \{60, 65\} \\ 1.00001, & \text{if } X \in \{70, 75\} \end{cases} \quad \textbf{(56)}$$

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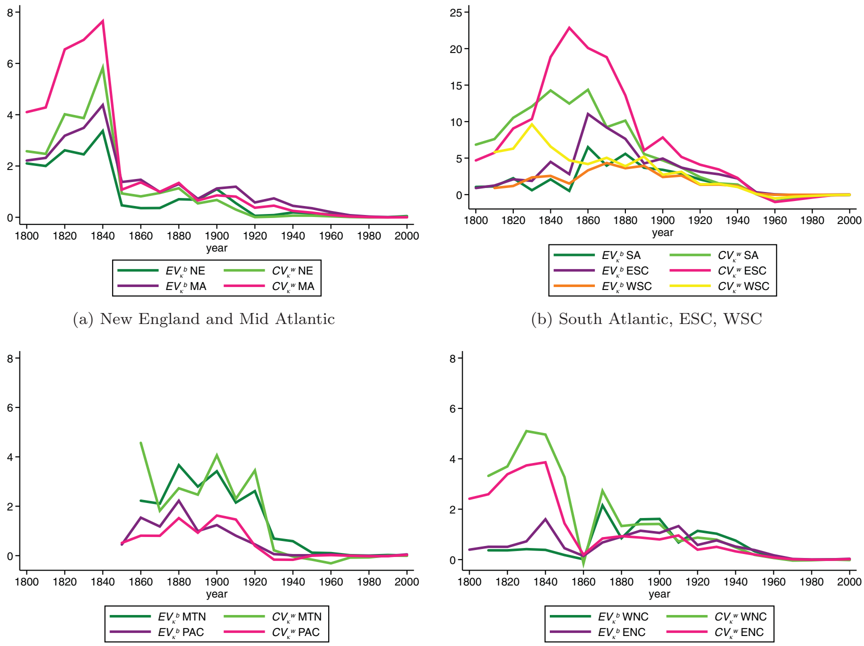

(a) New England and Mid Atlantic

(b) South Atlantic, ESC, WSC

(c) Mountain and Pacific

(d) WNC and ENC

FIGURE 19. (Colour online) EV_{κ}^{b}, CV_{κ}^{w}.

$$\omega_X = \begin{cases} 0.450, & \text{if } X = 5 \\ 0.525, & \text{if } X = 10 \\ 0.575, & \text{if } X = 15 \\ 1.00, & \text{if } X > 15 \end{cases} \tag{57}$$

The results of the goodness of fit of these regressions are contained in Tables 17 and 18. The fit for whites is extremely good. In every state, whites are the majority of the state population, and hence are most important in the determination of the state mortality. The average $\overline{R}^2$ is 0.999. Thus, our predicted white log survival probability is likely to be very accurate.

Our fit for blacks is a tad bit lower. There are quite a few states in which blacks are a very small minority of the state population. Nonetheless, the average $\overline{R}^2$ is 0.964. The column reporting the minimum $\overline{R}^2$ looks potentially worrisome. However, the number of states with $\overline{R}^2$ less than 0.81, and hence a correlation of less than 0.9, for all log survival regressions except for log infant survival, is either two or three.[55] Only log infant survival has more than three states, five, with an $\overline{R}^2$ less than 0.81.[56]

For missing values of log survival probabilities for blacks (whites), we used the predicted value from these regressions. We then produce estimates of black (white) probabilities of dying before age X, i.e. 1 – survival probability to age X. For those observations in which we

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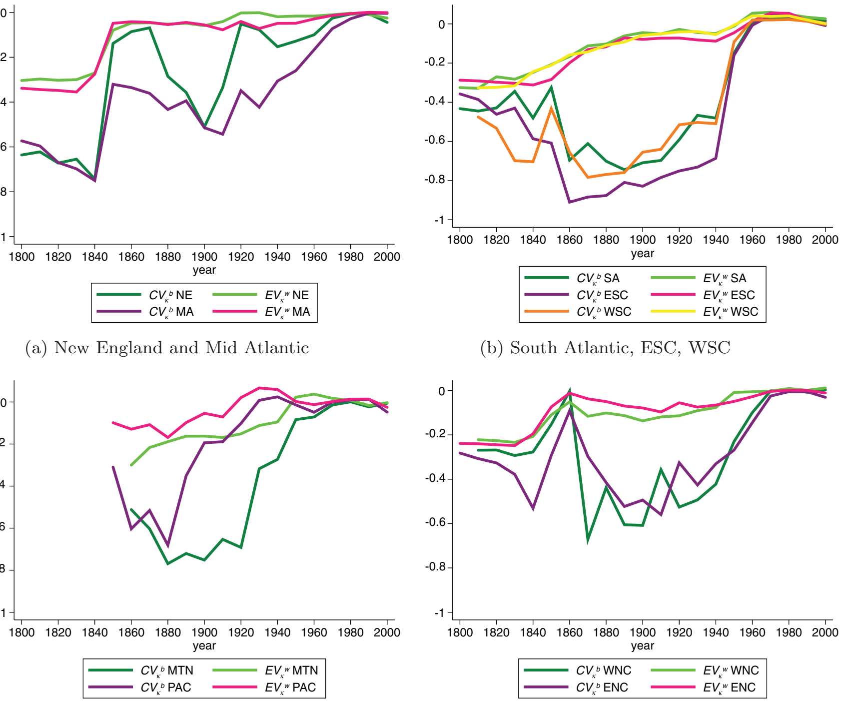

(a) New England and Mid Atlantic

(b) South Atlantic, ESC, WSC

(c) Mountain and Pacific

(d) WNC and ENC

FIGURE 20. (Colour online) EV_{κ}^{w}, CV_{κ}^{b}.

have predicted values of death probabilities, and interpolated values of death probabilities, we then take the arithmetic average of the two values, for blacks and whites.

Finally, we use these estimates along with those that come from the reported deaths contained in the censuses (covering years 1850–1900, inclusive) to produce our final estimates of death probabilities for years 1850–1900. We calculated the convex combination of the back-forecasted death probabilities and the census-derived measure:

$$p_{i0t}^{b} = p_{i0t}^{b,census}\beta_t + \hat{p}_{i0t}^{b}(1-\beta_t) \quad \textbf{(58)}$$

$$p_{i0t}^{w} = p_{i0t}^{w,census}\alpha_t + \hat{p}_{i0t}^{w}(1-\alpha_t). \quad \textbf{(59)}$$

The weights were chosen so as to match the national infant mortality rate reported in *Historical Statistics of the United States* (2006) for whites 1850–1900, and blacks 1850 & 1900. For whites, we exactly fit the national data, and for blacks we fit 1850 and 1900.[57] For blacks in the years 1860–1890, inclusive, we log linearly interpolated the weights 1850 and 1900. We report the weight on the Census death measures for whites and blacks over the 1850–1900 period in Table 19.

For years after 1900 and before the year, the state became a death registration state, we used our forecasted estimates from above, as there are no census reports of deaths to blend. For years 1800(20)–1840 and state i, we used the race specific state i average mortality over

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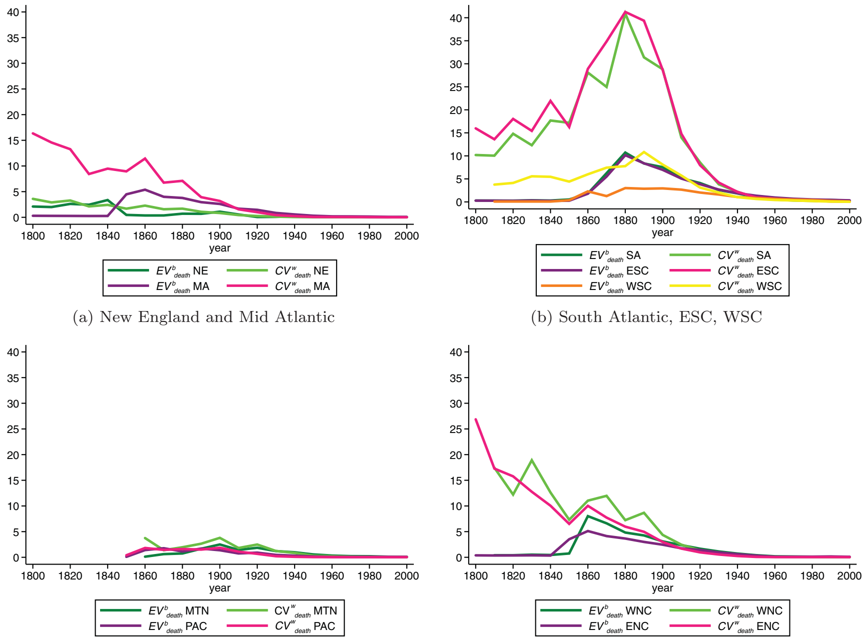

(a) New England and Mid Atlantic
(b) South Atlantic, ESC, WSC
(c) Mountain and Pacific
(d) WNC and ENC

FIGURE 21. (Colour online) EV^b_{death}, CV^w_{death}.

1850–1890. The divisional average probability of dying before age 45 years, middle-age, are graphed in Figures 15 and 16. The divisional average probability of dying before 75 is graphed in Figures 17 and 18. As with infant mortality, and mortality before 15, there has been a powerful decline in mortality risk. Furthermore, there is strong evidence of convergence across census divisions, and across race.

7.2. Black and White Fertility and Schooling

For fertility measures 1890–1990, we used the censuses of 1910, 1940–1990. In these censuses, women were asked how many children were ever born alive to them. The answers were reported by age category, and we focus on the 35–44 ever married group. The averages are also reported for ever married women 45–54 and ever married women 55 and older. We used these latter two categories to produce fertility measures for 1890, 1900, 1920, and 1930. For 2000, we used the 1998, 2000, 2002, and 2004 waves of the CPS that asked children ever born to women 35–44. For years prior to 1890, we used the same procedure detailed in our (2008) paper. A brief description is given below.

7.2.1. Black fertility 1820–1880. For 1820, we have census measures of black children under the age of 16 years. We computed the number of black children 0–15 relative to the number of black women aged 16–44 years, n^b_{0-15}. We then assumed that

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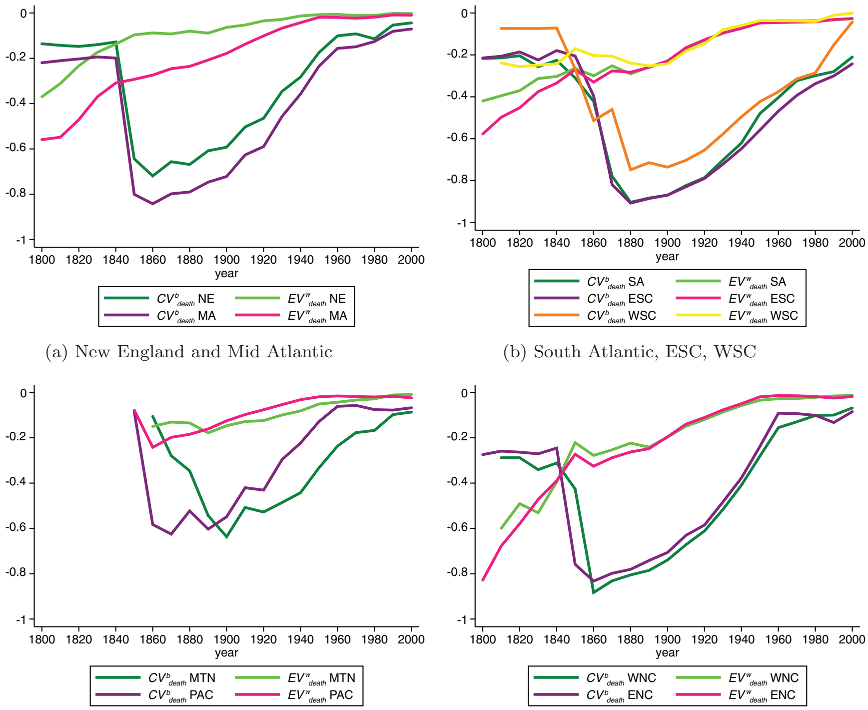

(a) New England and Mid Atlantic
(b) South Atlantic, ESC, WSC
(c) Mountain and Pacific
(d) WNC and ENC

FIGURE 22. (Colour online) EV^w_{death}, CV^b_{death}.

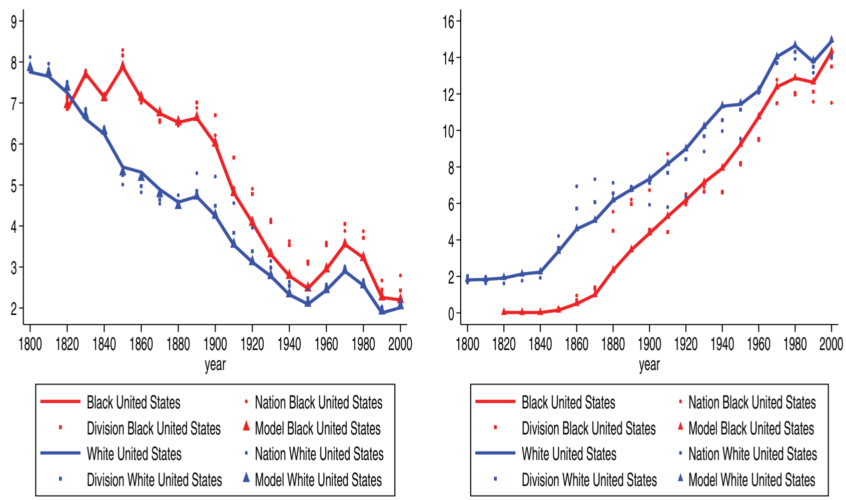

FIGURE 23. (Colour online) Cohort black and white fertility and schooling.

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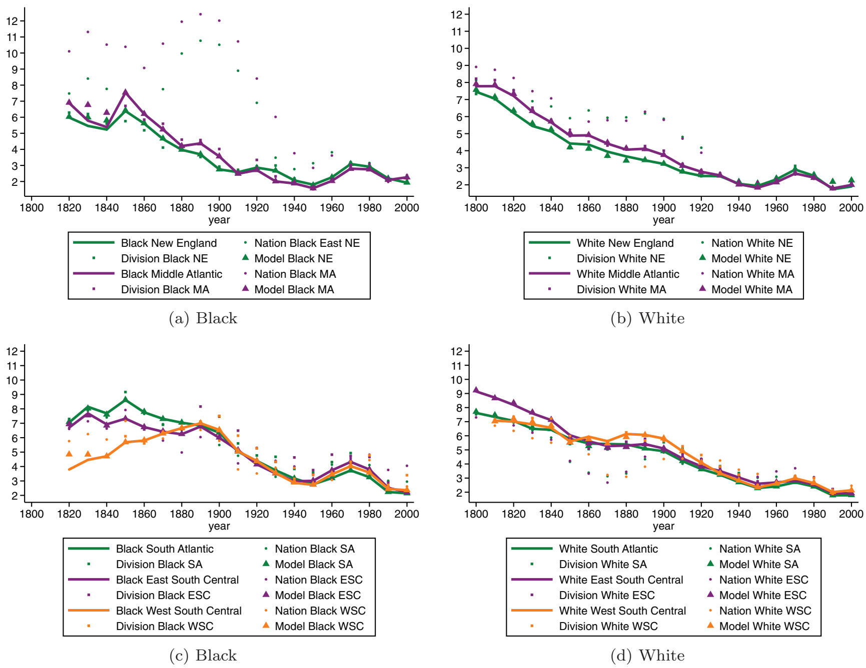

FIGURE 24. (Colour online) Cohort black and white fertility.

lifetime black fertility in 1820 is given by

$$x^b_{1820} = \frac{n^b_{0-15}}{1 - p^b_{15}}, \tag{60}$$

where p^b_{15} is the probability of dying before the age of 15 years. Given the large probability of dying before age 15 years for blacks in 1820, the average is 40%, with a range of 24.5% and 69%, we assumed that this is a good measure of completed fertility as black women would have continually had children to replace lost children. For example, the black infant mortality rate in 1820 was 280 per 1000 live births.[58]

For years 1830 and 1840, we have census measures of black children under the age of 10 years. We computed the number of black children 0–9 relative to the number of black women aged 16–44 years, $n^b_{t,0,9}$. We then assumed that lifetime black fertility in 1830 and 1840 are given by

$$x^b_t = \frac{n^b_{t,0-9}}{1 - p^b_{t,10}}, \tag{61}$$

where $t = 1830$, 1840, and $p^b_{t,10}$ is the probability of a black child dying before reaching the age of 10 years. Again because infant mortality is so high, 275 and 267 per 1000 live births, respectively, we assume that black mothers are continually replacing children that die. The average probabilities of dying before age 10 years for these years are 38.4% and

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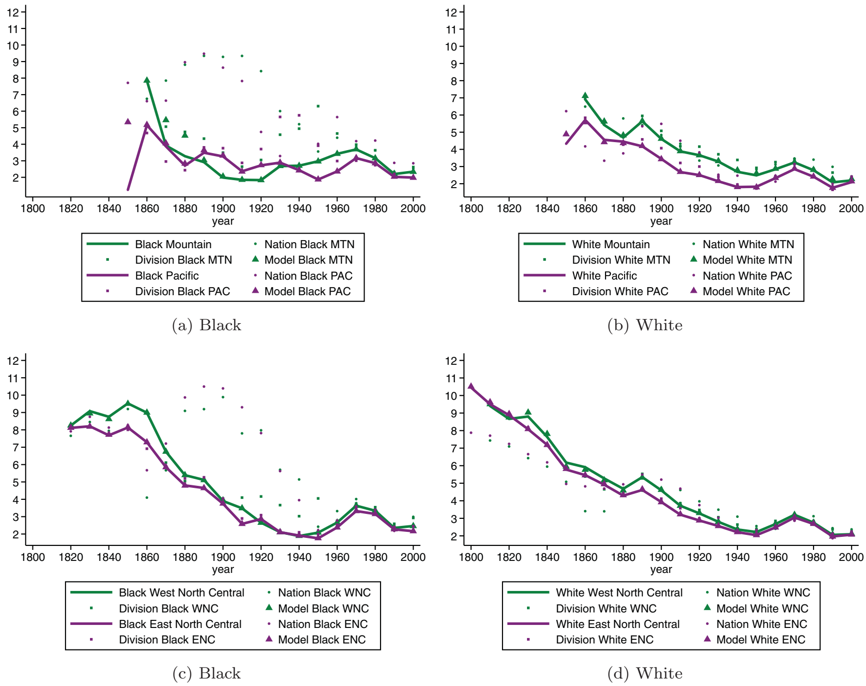

FIGURE 25. (Colour online) Cohort black and white fertility.

37.2%, respectively. Overall for 1820–1840, our measure of black fertility is quite similar to a total fertility rate.[59]

For 1850–1880, inclusive, we use different information to produce a synthetic total fertility rate. In these years, the census provides the number of black children under the age of 1, $n^b_{t,0}$, and the number of black children between 1 and 4, $n^b_{t,1-4}$, inclusive, relative to the number of black women aged 16–44 years. Thus, to produce our estimate of state black fertility we used

$$x^b_t = 6\left\{\frac{n^b_{t,0}}{1-p^b_{t,0}} + \frac{n^b_{t,1-4}}{1-p^b_{t,5}}\right\}, \quad \textbf{(62)}$$

where $p^b_{t,0}$ is black infant mortality in the state in year t, and $p^b_{t,5}$ is the state black probability of dying before age 5 years. Unlike the previous years 1820–1840, we adjust the measure by multiplying by 6. We believe that looking at the much younger cohort of children, ages 0–4 years, is too short a horizon to fully account for total live births per woman. Also, the series fits quite well between the 1820–1840 period and the 1890–1910 period.

7.2.2. White fertility 1800–1880. For whites in years 1800–1840, we used the same procedure as for blacks for 1830–1840. We used census estimates of children under the age of 10 years per white women aged 16–44 years, $n^w_{t,0-9}$, and our estimates of the probability of dying before the age of 10 years, $p^w_{t,10}$. Thus, our estimate of state white fertility for these

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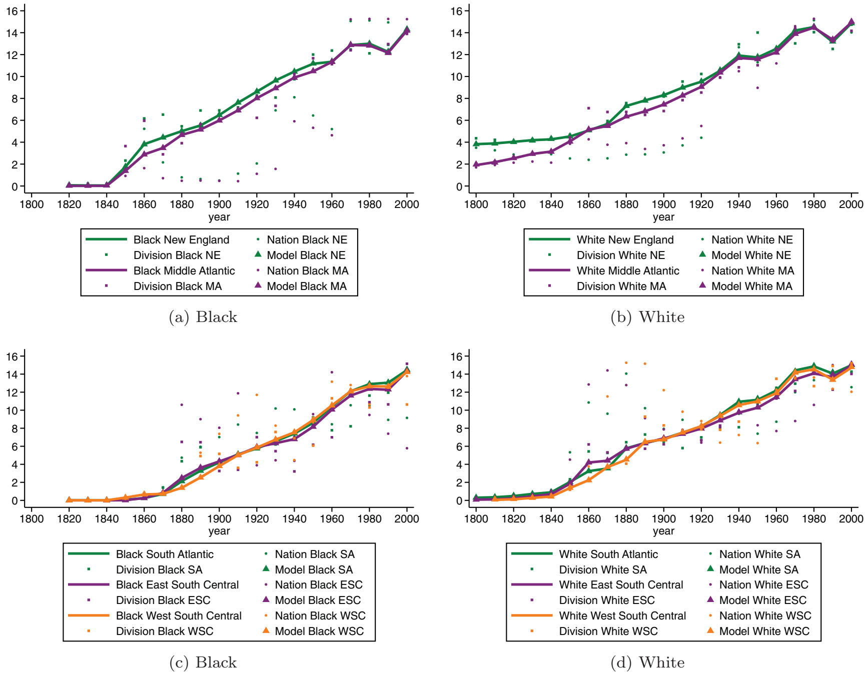

FIGURE 26. (Colour online) Cohort black and white schooling.

years is given by

$$x_t^w = \frac{n_{0-9}^w}{1 - p_{t,10}^w}. \tag{63}$$

As with black fertility, we chose not to multiply this value by 3 or 2.[60] Comparing our estimates for years 1800–1840 shows that this measure is larger than the comparable year total fertility rate estimate from Haines. However, our 1830 and 1840 values are both quite close to his national estimates. In 1830, we are 1.8% higher, and in 1840 we are 2.6% higher. However, in the earliest years, 1800–1820, we exceed Haines estimates by 11.2%, 11.5% and 8.6%, respectively.

For 1850–1880, we followed the same procedure as for blacks. That is we compute a measure of white fertility as

$$x_t^w = 6\left\{\frac{n_{t,0}^w}{1 - p_{t,0}^w} + \frac{n_{t,1-4}^w}{1 - p_{t,5}^w}\right\}, \tag{64}$$

where $n_{t,0}^w$ is the number of white children under the age of 1 year relative to the white female population aged 16–44 years, $n_{t,1-4}^w$ is the number of white children between the ages of 1 and 4 years, inclusive, relative to the white female population aged 16–44 years, $p_{t,0}^w$ is the white infant mortality rate, and $p_{t,5}^w$ is the white probability of dying before the age of 5 years. Table 20 shows that our fit with Haines national total fertility estimate for

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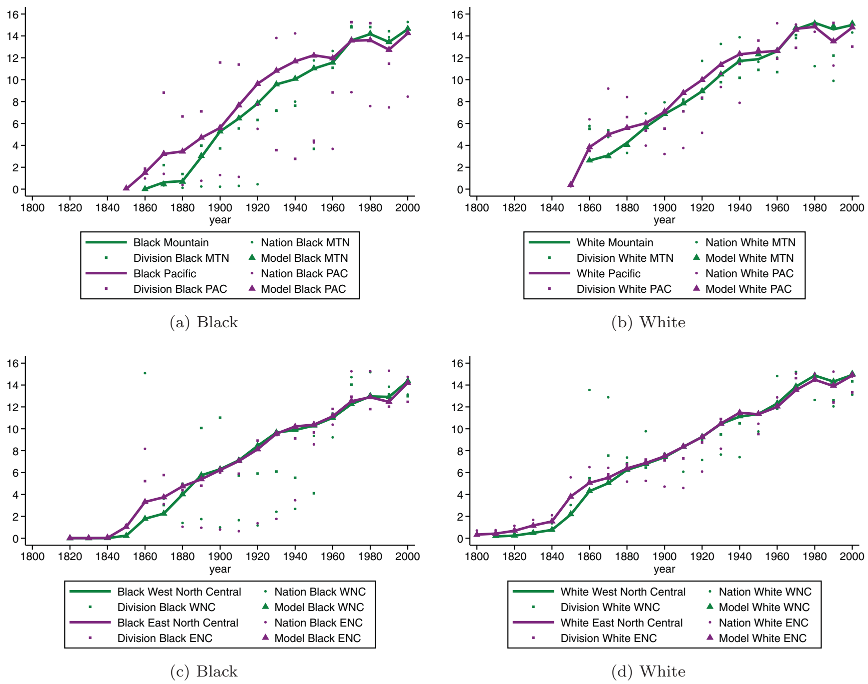

FIGURE 27. (Colour online) Cohort black and white schooling.

whites is quite good. The percent errors for these years for whites are: −2.4%, −0.6%, 4.6%, and 5.4%, respectively. A simple average of these four years produces 4.925 children per woman for our series and 4.855 for Haines.

Our fertility measure is total live births for women ever married aged 35 to 44 years in the year reported for years 1890–2000, and are contained in Table 1. For years prior to 1890, our measure is akin to a total fertility rate. For blacks, our 1850 value is very close to the national black estimate from Haines. Our 1860–1880 values are slightly below Haines' national black estimates. Thus, we feel comfortable that our 1850–1880 procedure, multiplying by 6, is a good approximation to overall total fertility rates for black women in these years. Our estimates for 1820–1840, we also believe are reasonable. The percent error for 1850–1880 between our estimates of black fertility and Haines national black total fertility rates are: −0.3%, −6.0%, −12.4%, −10.1%. The average % deviation is −7.2%. Absent additional information, we are not comfortable multiplying by greater than 6, since for the 1850–1880 period, we are using essentially the relative number of children under the age of 5 years compared with the number of black women aged 16–44 years. Thus, it would seem that we are looking at something like 5 years of completed fertility, at the largest, compared with 30 years of fertile child bearing years. Furthermore, this procedure works well for whites, although, we slightly overestimate white total fertility rates, and this overestimate is rising over time.[61] The largest discrepancy between our estimates and those from Haines, occur in 1950, 1960, and 1980. These correspond with the Baby Boom years and the Baby Bust year. In 1950, our fertility estimates reach a local minimum: fertility of

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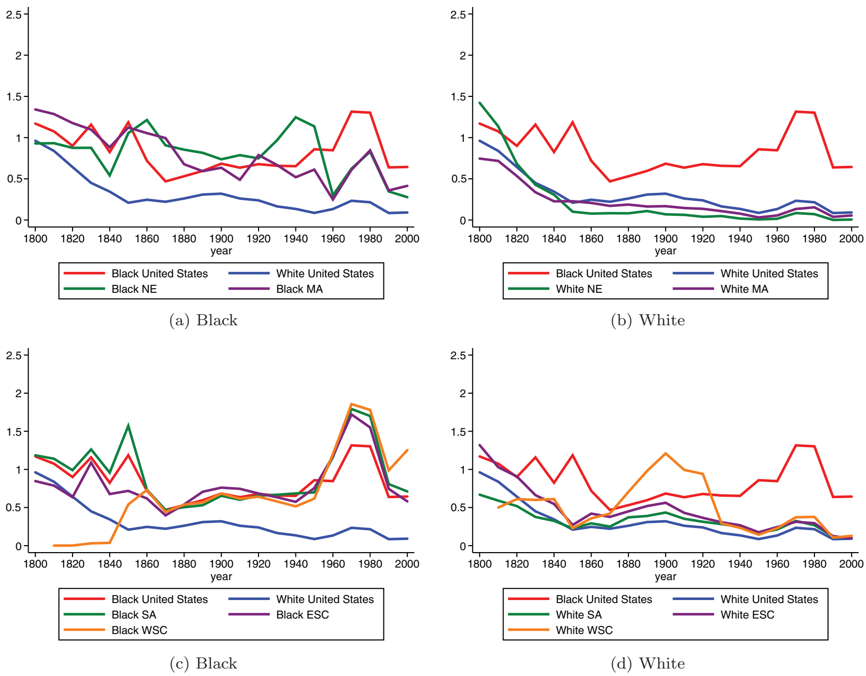

FIGURE 28. (Colour online) Black and white β.

2.09 and 2.48 for white and black ever married 35 to 44 women. However, since the Baby Boom begins in 1946, the sharp increase in the hazard rate of births to the younger age cohort, 15–24 years and 25–34 years causes the total fertility rate, reported by Haines, to differ by 0.9 white children, and 1.45 black children. In 1960, our white and black estimates are too low by 1.09 white children and 1.50 black children. The 1980 Baby Bust in Haines' estimates occur before our estimates return to pre 1960 levels. Thus in 1980, our measures are too large by 0.78 white children and 1.04 black children. Over the entire overlapping years 1890–2000, our children ever born measures are on average 4.6% too high for white fertility and 1.2% too high for black fertility. For the 1800–1880, white fertility period, and 1820–1880 black fertility period, our average deviation from Haines is 4.8% for whites, and −7.2% for blacks. Thus, we feel our black and white fertility measures over the entire period are accurate and reasonable measures of true underlying fertility for blacks and whites.

7.2.3. Black and white schooling. For schooling, we used a similar procedure as Turner, Tamura, Mulholland and Baier (2007) and in our 2008 paper. The only exceptions to this were the assumed age of the children, and also the additional computation of years of schooling prior to 1850. In our earlier paper, we assumed that for a year X cohort of women aged 35–44 years, the children in year X are 6 years old. Thus, we computed expected years of schooling for that birth cohort by adding the enrollment rates (potentially capped at 100%) from year X to year X+18. This assumes that the median mother was 33.5 years

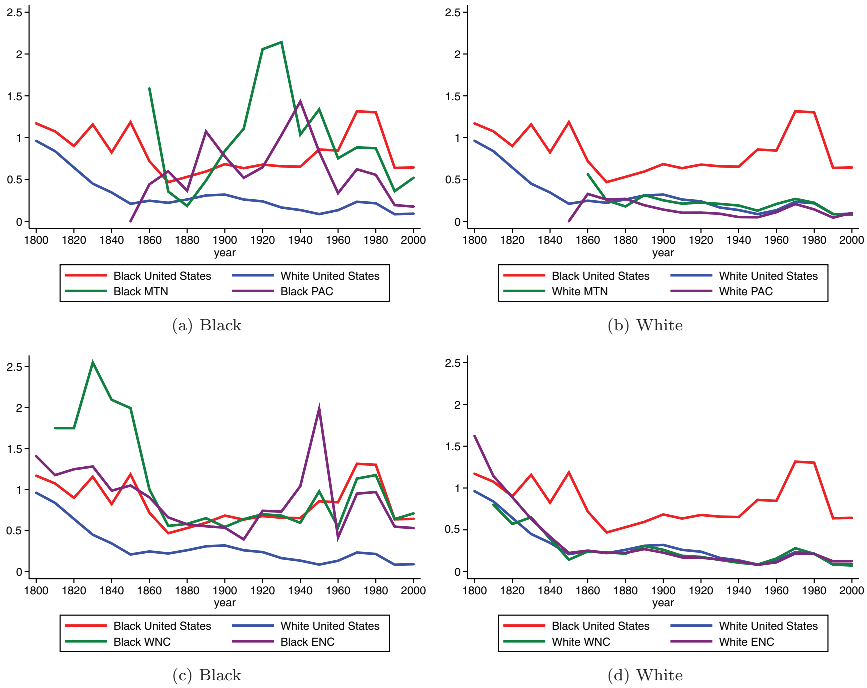

FIGURE 29. (Colour online) Cohort black and white β.

old when the children were born. For this paper, we decided to assume the child was 11 years old in year *X*. Thus, we assumed that the median mother was 28.5 years old when the children were born, which we believe better fits the age distribution of births. For white schooling estimates prior to the 1850 cohort, we used the ten year growth rate of schooling between 1850 and 1860 to back solve for schooling. In rare instances schooling fell between 1850 and 1860, and then we assumed that the growth rate of schooling from 1850–1870 prevailed. For blacks, prior to the end of slavery, we typically assumed that the years of schooling were constant, and equal to their value in 1850.

7.3. Model Fit

Figure 23 shows comparisons of the model solutions for black and white fertility and black and white schooling with the data. The data are displayed as solid lines. State-level solutions, that is allowing $(\beta_{iRt}, \nu_{iRt}, \kappa_{it}^{R})$ to vary by race, R, state, i, and year t, are represented as triangles. Division-level solutions, that is allowing (β_{DRt}, ν_{DRt}) to vary by race, census division, D, and year, are represented as smaller squares.[62] Nation solutions, that is allowing (β_{Rt}, ν_{Rt}) to vary by race and year, are represented as circles.[63] Figures 24–27 contain the data for black and white fertility, black and white schooling by census division. The figures contain the data, as well as the division averages arising from black and white nation preferences, division preferences and state preferences.[64]

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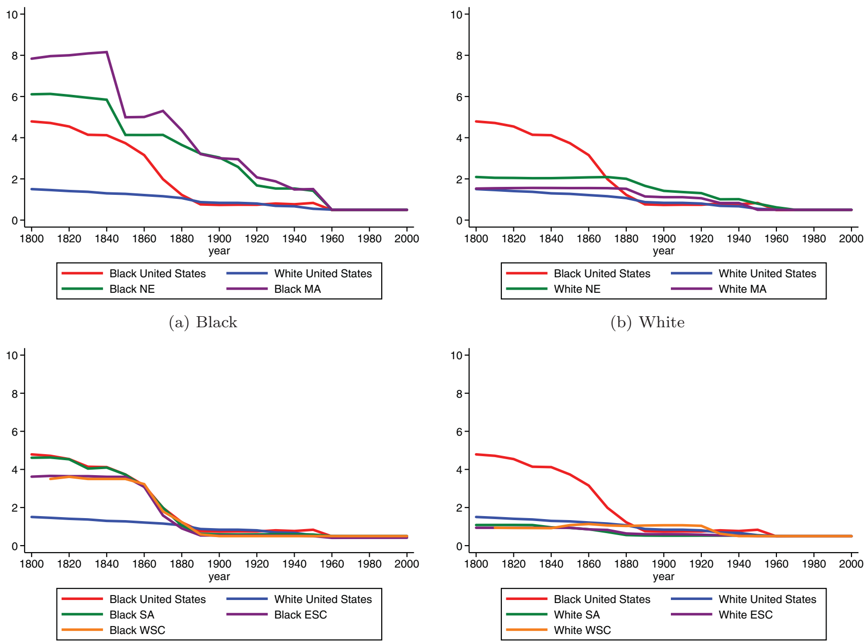

(a) Black (b) White
(c) Black (d) White

FIGURE 30. (Colour online) Black and white ν.

Recall Table 6 of the paper presents the goodness of fit of the calibrated nation preference, division preference and state models with respect to black and white national, and divisional fertility and schooling, respectively. Also Table 7 of the paper shows how well the state model fits all observations. Tables 21 and 22 augment these measures of fit, and contain the results of regressions by race of state fertility data against nation and division preference model solution fertility, and state schooling data on nation and division model solution schooling. In each case, we regress the log of the white outcome data on the log of the white model solution, as well as the log of the black outcome data on the log of the black model solution. Table 21 presents the fit with nation, time varying preferences by race, while Table 22 provides the fit for division, time varying preferences by race. In the first column of each table, we regress the data on all years. The next two columns present regression results for the $19th$ century and the $20th$ century (2000 included), respectively. The penultimate column contains the pre 1960 years, and the final column contains the 1950–2000 period.[65] The final row of each panel contains the p-value of the joint hypotheses that $\beta = 1, \alpha = 0$. Under nation preferences, the average $\overline{R}^2 = 0.5586$. For a panel, this is pretty unimpressive. Our fit improves when we allow preference heterogeneity at the division level. The average $\overline{R}^2 = 0.6272$. In the 20 cases, the $\overline{R}^2$ increases 16 times. Finally, under state preferences the average $\overline{R}^2 = 0.9371$. The weakest fits have $\overline{R}^2 = 0.8585$, post 1940 white fertility, and $\overline{R}^2 = 0.7668$, pre 1900 black fertility. We are certainly able to match the data well, with increasing fit as preferences are allowed more heterogeneity. Schooling is a trended

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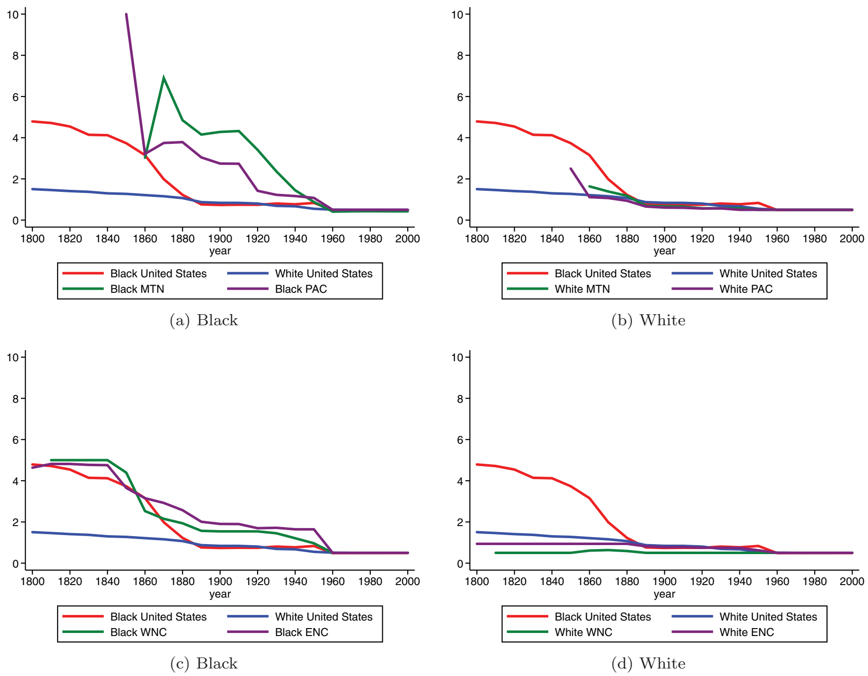

FIGURE 31. (Colour online) Cohort black and white ν.

variable, and hence is easier to fit than fertility. Still the overall fit, given by the results in the base column, indicate that the model can replicate the observed fertility data for whites and blacks. There is very little difference in the model's ability to fit black or white fertility, when preferences are state specific.

8. WELFARE COST ESTIMATES BY DIVISION & ROBUSTNESS

The welfare costs of unequal education access are presented graphically by census division, and race below. The three southern divisions have the highest measured welfare costs.

In Tables 23 and 24, we reproduce welfare cost measures of unequal education access using nation preferences and division preferences. In both cases, the magnitudes of our welfare cost measures are very similar. In Table 25, we show that the correlations are quite high. Recall that two of our measures will be negative under unequal access, and two will be positive under unequal access.[66] The average absolute value of these correlations is 0.69. The within welfare measure correlation averages, that is looking at the same welfare measure, but varying the level of preference aggregation, are higher. They are: $\Delta^b = 0.77$; $\Delta^w = 0.92$; $\Omega^b = 0.77$, and $\Omega^w = 0.96$. Thus, preference aggregation does not change our estimates of the welfare costs of unequal education access.

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TABLE 21. Pooled regressions of log actual observations on log model solutions: Nation preferences

	Base	Pre 1900	Post 1890	Pre 1960	Post 1940
			White fertility		
β	0.5146***	0.1074***	0.5569***	0.3543***	0.5320***
	(0.0252)	(0.0324)	(0.0298)	(0.0306)	(0.0405)
α	0.5847***	1.5530***	0.3689***	0.8886***	0.3088***
	(0.0391)	(0.0608)	(0.0364)	(0.0520)	(0.0413)
N	891	342	549	636	304
$\bar{R}^2$	0.6495	0.8198	0.6816	0.6814	0.5169
p	0.0000	0.0000	0.0000	0.0000	0.0000
			White schooling		
β	0.6763***	0.6846***	0.1569***	0.6512***	0.1240***
	(0.0215)	(0.0340)	(0.0160)	(0.0260)	(0.0173)
α	0.5879***	0.1990***	2.0471***	0.5027***	2.2937***
	(0.0484)	(0.0666)	(0.0380)	(0.0555)	(0.0429)
N	891	342	549	636	304
$\bar{R}^2$	0.4009	0.5594	0.5917	0.3906	0.8940
p	0.0000	0.0000	0.0000	0.0000	0.0000
			Black fertility		
β	0.1857***	− 0.2067***	0.1017***	0.0887**	0.3143***
	(0.0326)	(0.0634)	(0.0307)	(0.0425)	(0.0464)
α	0.9513***	2.1207***	0.8530***	1.1894***	0.5849***
	(0.0623)	(0.1293)	(0.0502)	(0.0864)	(0.0568)
N	843	294	549	588	304
$\bar{R}^2$	0.3383	0.5487	0.3118	0.3575	0.2879
p	0.0000	0.0000	0.0000	0.0000	0.0000
			Black schooling		
β	0.6599***	0.7628***	0.1176***	0.6652***	0.0272**
	(0.0162)	(0.0253)	(0.0097)	(0.0201)	(0.0120)
α	0.7499***	0.3941***	2.0643***	0.6225***	2.4525***
	(0.0681)	(0.1201)	(0.0252)	(0.0947)	(0.0293)
N	843	294	549	588	304
$\bar{R}^2$	0.6145	0.7594	0.3345	0.6227	0.8107
p	0.0000	0.0000	0.0000	0.0000	0.0000

Table reports results from pooled regressions with errors corrected for panel autocorrelation and Prais–Winsten heteroskedastic error correction. The final row, marked p, is the p-value on the null hypothesis that $\beta = 1$ and $\alpha = 0$.

8.1. Mortality Differences

We also present the welfare costs measures of higher mortality risks faced by blacks. Tables 26 and 27 present the welfare costs of higher black mortality by census division and time period. As with our measures of the welfare cost of unequal access to education, these tables show that our measures are robust to preference aggregation.

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TABLE 22. Pooled regressions of log actual observations on log model Solutions: Division preferences

	Base	Pre 1900	Post 1890	Pre 1960	Post 1940
			White fertility		
β	0.6733***	0.4236***	0.5524***	0.5758***	0.5031***
	(0.0220)	(0.0450)	(0.0311)	(0.0288)	(0.0415)
α	0.3645***	0.9864***	0.3935***	0.5626***	0.3559***
	(0.0324)	(0.0815)	(0.0354)	(0.0459)	(0.0396)
N	891	342	549	636	304
$\bar{R}^2$	0.7338	0.8427	0.6929	0.7557	0.5013
p	0.0000	0.0000	0.0000	0.0000	0.0000
			White schooling		
β	0.8165***	0.8703***	0.1399***	0.7950***	0.1016***
	(0.0177)	(0.0285)	(0.0166)	(0.0221)	(0.0178)
α	0.3888***	0.1286***	2.0749***	0.3488***	2.3414***
	(0.0377)	(0.0435)	(0.0407)	(0.0432)	(0.0449)
N	891	342	549	636	304
$\bar{R}^2$	0.6938	0.7968	0.6192	0.6648	0.8964
p	0.0000	0.0000	0.0000	0.0000	0.0000
			Black fertility		
β	0.3133***	0.1670**	0.2579***	0.2417**	0.3626***
	(0.0316)	(0.0774)	(0.0302)	(0.0435)	(0.0373)
α	0.7951***	1.3918***	0.6708***	0.9654***	0.5443***
	(0.0540)	(0.1521)	(0.0426)	(0.0777)	(0.0446)
N	843	294	549	588	304
$\bar{R}^2$	0.3968	0.5322	0.3664	0.4060	0.3366
p	0.0000	0.0000	0.0000	0.0000	0.0000
			Black schooling		
β	0.7125***	0.7392***	0.1113***	0.7122***	0.0490***
	(0.0146)	(0.0214)	(0.0126)	(0.0180)	(0.0109)
α	0.5349***	– 0.0671	2.0306***	0.4140***	2.4037***
	(0.0534)	(0.0960)	(0.0321)	(0.0728)	(0.0266)
N	843	294	549	588	304
$\bar{R}^2$	0.7100	0.8153	0.2901	0.7126	0.7797
p	0.0000	0.0000	0.0000	0.0000	0.0000

Table reports results from pooled regressions with errors corrected for panel autocorrelation and Prais–Winsten heteroskedastic error correction. The final row, marked p, is the p-value on the null hypothesis that $\beta = 1$ and $\alpha = 0$.

9. HUMAN CAPITAL AND OUTPUT

Finally, we present empirical estimates of the correlation between our measures of human capital and different measures of state output per worker, permanent income, and earnings. In Table 28 we report the results using Prais–Winsten regressions, correcting for panel serial correlation. These results are quite similar to those of the paper, and hence confirms

TABLE 23. Welfare cost of education discrimination, nation preferences (no DC): Black compensating variation $-\Omega^b$, white equivalent variation $-\Omega^w$, white compensating variation Δ^w, black equivalent variation Δ^b (all as proportion of black life time wealth)

Years	Welfare	NE	MA	SA	ESC	WSC	MTN	PAC	WNC	ENC	US
All	$-\Omega^b$	– 0.0892	– 0.1509	– 0.2040	– 0.2827	– 0.1807	– 0.0705	– 0.0255	– 0.1184	– 0.1254	– 0.1874
All	$-\Omega^w$	– 0.1367	– 0.1802	– 2.6327	– 4.3491	– 1.0574	– 0.1092	– 0.0025	– 0.3958	– 0.0975	– 1.8881
All	Δ^w	0.1776	0.2158	3.5144	5.7120	1.3094	0.1520	0.0063	0.4703	0.1054	2.4888
All	Δ^b	0.1399	0.2940	0.8674	1.4264	0.6706	0.1988	0.0339	0.2756	0.2412	0.7215
Pre 1870	$-\Omega^b$	– 0.3551	– 0.2832	– 0.4426	-0.6322	– 0.4575	– 0.5539	– 0.3779	– 0.1415	– 0.2152	– 0.4812
Pre 1870	$-\Omega^w$	– 2.0451	– 3.1576	– 12.623	– 15.348	– 4.3819	– 3.5701	– 0.7610	– 1.9496	– 1.4070	– 11.794
Pre 1870	Δ^w	2.9826	4.4877	19.353	22.399	5.6390	5.6671	0.8808	2.4599	1.7386	17.634
Pre 1870	Δ^b	1.1125	0.5586	2.4262	4.7594	1.7812	2.3169	0.6713	0.1925	0.3067	2.8610
1870–1890	$-\Omega^b$	– 0.0647	– 0.0840	– 0.5823	– 0.6114	– 0.7075	– 0.2460	– 0.1467	– 0.2484	– 0.0992	– 0.5695
1870–1890	$-\Omega^w$	– 0.6924	– 0.8959	– 9.9390	– 14.671	– 6.7089	– 2.0453	– 0.8837	– 2.2233	– 0.7028	– 9.9406
1870–1890	Δ^w	0.8476	0.9644	11.572	18.888	8.6492	2.5395	1.0544	2.6931	0.7406	12.246
1870–1890	Δ^b	0.1639	0.0961	3.2427	4.3358	3.5828	0.5393	0.1846	0.7900	0.1321	3.3404
1900-1950	$-\Omega^b$	– 0.1599	– 0.3856	– 0.3357	– 0.3501	– 0.2890	– 0.3148	– 0.0013	– 0.2968	– 0.4043	– 0.3326
1900–1950	$-\Omega^w$	– 0.1702	– 0.3954	– 1.2809	– 2.1888	– 0.9120	– 1.0133	0.0069	– 0.4540	– 0.3428	– 1.2351
1900–1950	Δ^w	0.1812	0.4270	1.3373	2.3031	0.9744	1.2970	0.0275	0.4961	0.3694	1.3016
1900–1950	Δ^b	0.2261	0.9056	0.9103	0.8554	0.7707	1.0636	0.0556	0.6862	0.9345	0.8511
Pre 1960	$-\Omega^b$	– 0.1741	– 0.3514	– 0.4050	– 0.4525	– 0.3793	– 0.3089	– 0.0080	– 0.2694	– 0.3702	– 0.3981
Pre 1960	$-\Omega^w$	– 0.5226	– 0.6741	– 5.1940	– 7.0281	– 2.2565	– 1.1056	– 0.0247	– 0.9883	– 0.4075	– 4.3891
Pre 1960	Δ^w	0.6906	0.8199	6.8607	9.1573	2.7603	1.4090	0.0638	1.1716	0.4440	5.7149
Pre 1960	Δ^b	0.3462	0.8076	1.6647	2.2429	1.3675	1.0184	0.0632	0.6524	0.8411	1.6050
1960–2000	$-\Omega^b$	– 0.0625	– 0.0887	0.0195	0.0147	0.0144	– 0.0347	– 0.0271	– 0.0159	– 0.0622	– 0.0197
1960–2000	$-\Omega^w$	– 0.0152	– 0.0267	0.2139	0.3436	0.1205	0.0404	– 0.0005	0.0061	– 0.0174	0.1096
1960–2000	Δ^w	0.0162	0.0281	– 0.2047	– 0.3231	– 0.1157	– 0.0367	0.0012	– 0.0054	0.0180	– 0.1035
1960–2000	Δ^b	0.0750	0.1345	– 0.0186	– 0.0038	– 0.0140	0.0758	0.0313	0.0200	0.0862	0.0338

Table reports our estimates of the welfare cost of discrimination in the cost of schooling, as a percent of black lifetime wealth. All values are weighted by black population.

TABLE 24. Welfare cost of education discrimination, division preferences (no DC): Black compensating variation $-\Omega^b$, white equivalent variation $-\Omega^w$, white compensating variation Δ^w, black equivalent variation Δ^b (all as proportion of black life time wealth)

Years	Welfare	NE	MA	SA	ESC	WSC	MTN	PAC	WNC	ENC	US
All	$-\Omega^b$	−0.0702	−0.1151	−0.2073	−0.3213	−0.1943	−0.0618	−0.0117	−0.1400	−0.0927	−0.1889
All	$-\Omega^w$	−0.1274	−0.1619	−2.3586	−4.0737	−1.0325	−0.0818	−0.0034	−0.4015	−0.0994	−1.7419
All	Δ^w	0.1680	0.1955	3.0117	5.0534	1.2267	0.1199	0.0066	0.4589	0.1075	2.1899
All	Δ^b	0.1385	0.2145	0.8633	1.6656	0.6723	0.1992	0.0235	0.3142	0.1456	0.7418
Pre 1870	$-\Omega^b$	−0.4432	−0.4874	−0.4103	-0.6746	−0.5710	−0.5248	−0.5636	−0.1327	−0.2560	−0.4951
Pre 1870	$-\Omega^w$	−2.0636	−3.2240	−10.934	−13.634	−4.0515	−3.5204	−0.6440	−1.9685	−1.4094	−10.364
Pre 1870	Δ^w	3.0177	4.5844	15.502	18.810	5.1776	5.5584	0.7291	2.4143	1.7203	14.485
Pre 1870	Δ^b	1.7606	1.9840	1.9778	5.0901	2.2991	2.2155	1.4247	0.1752	0.4374	2.8177
1870–1890	$-\Omega^b$	−0.2278	−0.3770	−0.5398	−0.5179	−0.6611	−0.6140	−0.4165	−0.5595	−0.3388	−0.5421
1870–1890	$-\Omega^w$	−0.6887	−0.9259	−8.1030	−11.820	−5.0953	−2.0217	−0.8399	−1.8641	−0.8346	−8.0153
1870–1890	Δ^w	0.8475	1.0000	9.5030	14.228	6.1517	2.4943	0.9876	2.0912	0.8878	9.5297
1870–1890	Δ^b	0.4867	1.1342	2.9026	3.6956	3.1490	2.3832	0.9454	1.5244	0.6047	3.0006
1900–1950	$-\Omega^b$	−0.1529	−0.3253	−0.3690	−0.4644	−0.3246	−0.3275	−0.0160	−0.2891	−0.3418	−0.3690
1900–1950	$-\Omega^w$	−0.1360	−0.3239	−1.6723	−3.0642	−1.3390	−0.8181	−0.0098	−0.5848	−0.3492	−1.6636
1900–1950	Δ^w	0.1430	0.3445	1.7703	3.3117	1.4712	1.0552	0.0387	0.6496	0.3761	1.7894
1900–1950	Δ^b	0.2189	0.5635	1.1497	1.5894	0.8245	1.2491	0.1321	0.6156	0.5850	1.0682
Pre 1960	$-\Omega^b$	−0.2066	−0.3435	−0.4107	−0.5102	−0.4064	−0.3528	−0.0314	−0.3276	−0.3390	−0.4194
Pre 1960	$-\Omega^w$	−0.5006	−0.6229	−4.7418	−6.6764	−2.2485	−0.9256	−0.0388	−1.0050	−0.4255	−4.1109
Pre 1960	Δ^w	0.6688	0.7627	5.9668	8.1921	2.6314	1.1846	0.0717	1.1461	0.4631	5.0785
Pre 1960	Δ^b	0.4843	0.7332	1.6559	2.6140	1.3705	1.3494	0.1646	0.7547	0.5826	1.6812
1960–2000	$-\Omega^b$	−0.0273	−0.0441	0.0188	0.0094	0.0140	−0.0181	−0.0099	−0.0128	−0.0291	−0.0055
1960–2000	$-\Omega^w$	−0.0100	−0.0187	0.2901	0.4854	0.1619	0.0449	−0.0002	0.0078	−0.0152	0.1549
1960–2000	Δ^w	0.0104	0.0193	−0.2727	−0.4446	−0.1531	−0.0399	0.0007	−0.0072	0.0156	−0.1438
1960–2000	Δ^b	0.0297	0.0533	−0.0176	0.0043	−0.0136	0.0266	0.0108	0.0154	0.0327	0.0099

Table reports our estimates of the welfare cost of discrimination in the cost of schooling, as well as the value of Civil Rights. The values are relative to black wealth. All values are weighted by black population.

TABLE 25. Correlation of welfare measures

	Δ^b_{it}	Δ^b_{Dt}	Δ^b_{t}	Δ^w_{it}	Δ^w_{Dt}	Δ^w_{t}	Ω^w_{it}	Ω^w_{Dt}	Ω^w_{t}	Ω^b_{it}	Ω^b_{Dt}	Ω^b_{t}
Δ^b_{it}	1.0000											
Δ^b_{Dt}	0.8171	1.0000										
Δ^b_{t}	0.7350	0.7714	1.0000									
Δ^w_{it}	0.7567	0.6372	0.6254	1.0000								
Δ^w_{Dt}	0.7454	0.6765	0.6766	0.9360	1.0000							
Δ^w_{t}	0.7138	0.6634	0.6948	0.8690	0.9587	1.0000						
Ω^w_{it}	− 0.7508	− 0.6341	− 0.6415	− 0.9831	− 0.9445	− 0.8933	1.0000					
Ω^w_{Dt}	− 0.7388	− 0.6609	− 0.6742	− 0.9313	− 0.9870	− 0.9478	0.9640	1.0000				
Ω^w_{t}	− 0.7242	− 0.6503	− 0.6891	− 0.8964	− 0.9545	− 0.9823	0.9386	0.9703	1.0000			
Ω^b_{it}	− 0.7941	− 0.6383	− 0.5138	− 0.5495	− 0.4847	− 0.4330	0.5133	0.4660	0.4410	1.0000		
Ω^b_{Dt}	− 0.6893	− 0.8035	− 0.5620	− 0.5165	− 0.4724	− 0.4259	0.4840	0.4529	0.4287	0.8460	1.0000	
Ω^b_{t}	− 0.6228	− 0.6186	− 0.7810	− 0.5201	− 0.4787	− 0.4474	0.4980	0.4665	0.4552	0.7267	0.7379	1.0000

Table reports the correlation of welfare measures across preference aggregation.

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TABLE 26. Welfare cost of differential mortality, nation preferences: Black compensating variation $-\Omega^b$, white equivalent variation $-\Omega^w$, white compensating variation Δ^w, black equivalent variation Δ^b (all as proportion of black life time wealth)

Years	Welfare	NE	MA	SA	ESC	WSC	MTN	PAC	WNC	ENC	US
All	$-\Omega^b$	– 0.2015	– 0.2574	– 0.3585	– 0.3711	– 0.2904	– 0.1799	– 0.1942	– 0.2670	– 0.2843	– 0.2901
All	$-\Omega^w$	– 0.2973	– 0.4394	– 5.3274	– 6.7777	– 1.4510	– 0.2471	– 0.0537	– 1.1767	– 0.2392	– 3.3667
All	Δ^w	0.3651	0.6147	7.3844	8.6258	1.7643	0.2951	0.0579	1.6333	0.2991	4.4916
All	Δ^b	0.3188	0.4744	1.5213	1.4155	0.7736	0.2870	0.2292	0.6422	0.3294	1.0216
Pre 1870	$-\Omega^b$	– 0.3392	– 0.5989	– 0.3228	– 0.3269	– 0.2768	– 0.0725	– 0.4382	– 0.4144	– 0.5863	– 0.4635
Pre 1870	$-\Omega^w$	– 2.9922	– 7.4907	– 14.746	– 12.719	– 4.3168	– 1.0918	– 1.1843	– 7.4244	– 5.5174	– 12.560
Pre 1870	Δ^w	4.0437	12.612	23.208	17.780	5.2662	1.2789	1.5019	11.108	8.0264	19.008
Pre 1870	Δ^b	1.1975	2.8087	1.2436	1.0050	1.3096	0.0933	0.9241	0.8455	2.5163	1.2489
1870–1890	$-\Omega^b$	– 0.3630	– 0.6122	– 0.7470	– 0.7966	– 0.6160	– 0.2272	– 0.3085	– 0.4945	– 0.6248	– 0.5923
1870–1890	$-\Omega^w$	– 2.4046	– 5.3756	– 22.638	– 25.135	– 7.3331	– 2.2428	– 1.4391	– 6.5341	– 4.4020	– 19.116
1870–1890	Δ^w	2.9551	7.5613	32.079	32.882	9.5212	2.9323	1.8638	9.3789	5.9589	26.136
1870–1890	Δ^b	0.9127	1.9443	6.6550	5.2870	2.6905	0.3581	0.4797	3.1919	2.4978	5.1809
1900–1950	$-\Omega^b$	– 0.3579	– 0.4423	– 0.5088	– 0.4396	– 0.4279	– 0.2696	– 0.1499	– 0.3863	– 0.4065	– 0.4558
1900–1950	$-\Omega^w$	– 0.4738	– 0.6835	– 4.7050	– 4.8687	– 1.5377	– 1.4518	– 0.2081	– 0.9858	– 0.5088	– 3.3348
1900–1950	Δ^w	0.5362	0.8159	5.5105	5.5144	1.6942	1.7741	0.2339	1.1711	0.5879	3.8437
1900–1950	Δ^b	0.6507	0.9181	1.9212	1.2307	1.0902	0.5433	0.2099	0.9310	0.7563	1.3834
Pre 1960	$-\Omega^b$	– 0.3756	– 0.4669	– 0.5240	– 0.4676	– 0.4605	– 0.2673	– 0.1561	– 0.4444	– 0.4324	– 0.4837
Pre 1960	$-\Omega^w$	– 1.1322	– 1.6618	– 10.133	– 10.530	– 2.8250	– 1.5210	– 0.2513	– 2.8572	– 1.0192	– 7.5843
Pre 1960	Δ^w	1.4125	2.3944	14.091	13.429	3.4178	1.8755	0.2910	3.9858	1.3073	10.157
Pre 1960	Δ^b	0.7700	1.1664	2.7184	2.0718	1.4005	0.5267	0.2225	1.3903	0.9706	2.0635
1960–2000	$-\Omega^b$	– 0.1467	– 0.1922	– 0.1798	– 0.2021	– 0.1233	– 0.1667	– 0.1809	– 0.1114	– 0.1344	– 0.1666
1960–2000	$-\Omega^w$	– 0.0345	– 0.0595	– 0.1378	– 0.2058	– 0.1014	– 0.0559	– 0.0360	– 0.0368	– 0.0378	– 0.0983
1960–2000	Δ^w	0.0355	0.0617	0.1417	0.2119	0.1044	0.0580	0.0369	0.0376	0.0387	0.1012
1960–2000	Δ^b	0.1768	0.2593	0.2286	0.2660	0.1577	0.2510	0.2298	0.1348	0.1638	0.2142

Table reports our estimates of the welfare cost of differential mortality. All values are weighted by black population.

TABLE 27. Welfare cost of differential mortality, division preferences: Black compensating variation $-\Omega^b$, white equivalent variation $-\Omega^w$, white compensating variation Δ^w, black equivalent variation Δ^b (all as proportion of black life time wealth)

Years	welfare	NE	MA	SA	ESC	WSC	MTN	PAC	WNC	ENC	US
all	$-\Omega^b$	– 0.1381	– 0.1806	– 0.4100	– 0.4661	– 0.3175	– 0.1512	– 0.0947	– 0.3047	– 0.3038	– 0.2914
all	$-\Omega^w$	– 0.1552	– 0.3398	– 5.8158	– 8.3165	– 2.1360	– 0.2394	– 0.0429	– 1.1713	– 0.2348	– 3.8876
all	Δ^w	0.1791	0.4495	7.9598	10.909	2.7178	0.2802	0.0456	1.6144	0.2989	5.2041
all	Δ^b	0.2383	0.3549	1.7323	1.8865	0.7308	0.2771	0.0755	0.8147	0.3150	1.1506
pre 1870	$-\Omega^b$	– 0.3133	– 0.4948	– 0.3320	– 0.3260	– 0.2628	– 0.1101	– 0.4748	– 0.6089	– 0.6277	– 0.4441
pre 1870	$-\Omega^w$	– 1.9852	– 6.5478	– 14.175	– 15.114	– 4.9404	– 1.6504	– 1.1711	– 7.2739	– 6.0968	– 12.929
pre 1870	Δ^w	2.4762	10.023	21.458	21.778	6.2709	2.1392	1.5071	11.203	9.5826	19.158
pre 1870	Δ^b	1.0718	2.0120	1.2240	1.0291	1.2920	0.1524	1.3358	3.5000	3.0394	1.2719
1870–1890	$-\Omega^b$	– 0.4888	– 0.7611	– 0.7412	– 0.7098	– 0.5636	– 0.3178	– 0.4465	– 0.6479	– 0.7239	– 0.6800
1870–1890	$-\Omega^w$	– 1.2579	– 4.2840	– 23.113	– 28.089	– 8.6345	– 2.2060	– 1.3108	– 6.3955	– 4.4435	– 20.363
1870–1890	Δ^w	1.3912	5.5826	32.617	37.875	11.741	2.8778	1.6515	8.9063	6.0452	28.122
1870–1890	Δ^b	1.5551	3.3635	6.5982	5.2342	1.7615	0.7977	0.9541	4.1501	3.1357	5.0774
1900–1950	$-\Omega^b$	– 0.3143	– 0.3764	– 0.5661	– 0.5718	– 0.4587	– 0.3706	– 0.0828	– 0.4042	– 0.3921	– 0.5071
1900–1950	$-\Omega^w$	– 0.2009	– 0.4837	– 6.1554	– 7.0141	– 2.9263	– 1.3190	– 0.1569	– 1.0328	– 0.4702	– 4.6209
1900–1950	Δ^w	0.2121	0.5481	7.5731	8.4061	3.5899	1.5753	0.1706	1.2305	0.5360	5.6234
1900–1950	Δ^b	0.5277	0.7757	2.4262	2.2173	1.0619	1.1865	0.1086	0.8749	0.8078	1.7885
pre 1960	$-\Omega^b$	– 0.3623	– 0.4153	– 0.5616	– 0.5521	– 0.4660	– 0.3702	– 0.0973	– 0.4960	– 0.4305	– 0.5189
pre 1960	$-\Omega^w$	– 0.6206	– 1.3232	– 11.007	– 12.891	– 4.1346	– 1.3972	– 0.1980	– 2.8437	– 1.0060	– 8.7299
pre 1960	Δ^w	0.7202	1.7837	15.127	16.956	5.2992	1.6901	0.2236	3.9388	1.3151	11.738
pre 1960	Δ^b	0.7618	1.0997	3.0132	2.6770	1.2086	1.1517	0.1417	1.8480	1.0907	2.3193
1960–2000	$-\Omega^b$	– 0.0675	– 0.1077	– 0.2463	– 0.3153	– 0.1717	– 0.1183	– 0.0649	– 0.0988	– 0.0990	– 0.1753
1960–2000	$-\Omega^w$	– 0.0087	– 0.0342	– 0.2103	– 0.3045	– 0.1729	– 0.0656	– 0.0290	– 0.0369	– 0.0356	– 0.1352
1960–2000	Δ^w	0.0088	0.0349	0.2194	0.3183	0.1822	0.0687	0.0296	0.0377	0.0365	0.1410
1960–2000	Δ^b	0.0735	0.1234	0.3490	0.5017	0.2615	0.1458	0.0696	0.1138	0.1147	0.2449

Table reports our estimates of the welfare cost of differential mortality. The values are relative to black wealth. All values are weighted by black population.

TABLE 28. Prais–Winsten regressions: $ln(y)$ top panel, g_y bottom panel; (standard error)

Variable y =	Output	Output	Output	Output	Permanent income black	Permanent income white	Earnings black	Earnings white
lnh	0.832	0.845	0.808	0.820				
	(0.032)	(0.033)	(0.031)	(0.031)				
lhh_{black}					0.305		0.342	
					(0.057)		(0.062)	
lnh_{white}						0.584		0.773
						(0.151)		(0.167)
Gold		0.808		0.779				
		(0.067)		0.057)				
Silver		1.070		1.057				
		(0.065)		(0.066)				
Constant	7.450	7.389	7.540	7.479	9.110	8.067	9.064	7.380
	(0.145)	(0.128)	(0.137)	(0.117)	(0.166)	(0.588)	(0.186)	(0.672)
Imputed data	yes	yes	no	no				
Division	yes	yes	yes	yes	yes	yes	yes	yes
N	890	890	788	788	515	551	390	404
$\overline{R}^2$	0.9928	0.9928	0.9947	0.9950	0.9858	0.9746	0.9847	0.9855

TABLE 28. Continued

Growth rates $g_y =$	Output	Output	Output	Output	Permanent income black	Permanent income white	Earnings black	Earnings white
g_h	0.437	0.419	0.570	0.536				
	(0.114)	(0.115)	(0.143)	(0.143)				
$g_{h_{black}}$					0.472		0.134	
					(0.159)		(0.211)	
$g_{h_{white}}$						0.965		– 0.525
						(0.757)		(0.858)
Gold		– 0.036		– 0.032				
		(0.006)		(0.006)				
Silver		– 0.024		– 0.023				
		(0.006)		(0.006)				
Constant	0.003	0.005	0.000	0.002	– 0.015	– 0.020	0.007	0.015
	(0.004)	(0.004)	(0.005)	(0.004)	(0.009)	(0.020)	(0.010)	(0.016)
Imputed data	yes	yes	no	no				
Division	yes	yes	yes	yes	yes	yes	yes	yes
N	839	839	737	737	464	500	339	353
$\bar{R}^2$	0.1303	0.1456	0.1302	0.1449	0.0868	0.1229	0.0582	0.1223

our view that the model's time series of black and white human capital are indeed highly correlated with measures of productivity.

NOTES

1 The only observable data to match for all the years are race specific fertility and schooling, by state. We do observe the state and race specific population density, which we assign as the price of space. We do not observe earnings, permanent income, housing, or consumption over the period. Thus, our model relies on the ability to reduce the choice of adult consumption, and housing to linear functions of wealth. Thus, by fitting fertility and schooling by race and state, the model can be calibrated. It produces an efficiency of schooling by race and state. We do require that there exists some preference heterogeneity across states and race in order to fit the data. However, our aggregation results suggest that these do not change our measures of the welfare costs of schooling discrimination, or differential mortality.

2 In Murphy, Simon and Tamura (2008), we show that the most densely populated states experienced the greatest increase in fertility during the 1950–1970 period. These states also illustrated a decline in the population density affecting the typical individual in the state. When extending the analysis to blacks and whites separately by state, we noticed that blacks in every state of the US had a large increase in fertility during the 1950–1970 period. This contrasts with very small fertility increases for whites in most southern states. This led to our interest in the possibility that the expansion of Civil Rights during the 1950s and 1960s induced an increase in black fertility. Our black and white population density calculations do not assume that the two groups are segregated. If there are two different people living in state i, one white and one black, and living in the same county, they would be computed as having the same population density in this county. However, the typical black and white do not live in the same counties. So black and white state population densities can differ without assuming anything about either the existence of segregation or lack of segregation of the races.

3 For 1890–1990, we collected information on children ever born by race back to 1890 from the decennial Censuses and, for 2000, from fertility supplements to the 1998–2004 Current Population Surveys. White fertility data for 1800–1840 are based on data from Yasuba (1962) and 1820–1840 black age distribution in the *Fifth Census of the United States*, adjusted using survival-probability information on the population under 10 years old. Fertility rates are obtained by dividing fertility by the population of black or white women age 16–44 years. Fertility for 1850–1880 is constructed similarly, but adjusted for survival of the population age 0–5 years, and divided by the population of women age 15–44 years. For years 1800–1840 (whites) and 1820–1840 (blacks) survival is 1 minus the average probability of dying before 10 for years 1850–1890. Finally, we assume that mothers give birth between the ages of 24 and 33 years. Thus, a cohort of children born in 1959 will be assigned to women between the ages of 35 and 44 years in 1970. In other words, we assume the year t birth cohort was born in year $t - 11$. See Appendix for more detail.

4 The cohort of women age 35–44 years in 1950 was born between 1906 and 1915, and in 1970 between 1926 and 1935. The small spike in fertility in 1890, visible for both races, is likely an artifact of the estimation procedure, necessary to produce figures for children ever born prior to 1890.

5 Indeed this discovery of the differential magnitudes of the Baby Boom for whites and blacks inspired this paper. The expansion of educational opportunities for black children starting in the 1950s could have dramatically increased fertility for blacks in all regions.

6 Table 3 shows data from 1850 to keep the Table on a single page. These figures are not adjusted for migration. See Appendix for more detail. We basically use the procedure from Turner, Tamura, Mullholland and Baier.

7 In Tamura and Simon (2015), which uses a similar model to fit the time series of fertility and schooling for 21 countries, the rise in schooling is found to require a similar decline in schooling cost. The model's fitted schooling cost series is closely correlated with national level data on expenditures per pupil relative to per capita income.

8 See our Appendix for figures of probability of dying before age 45 years and age 75 years, respectively.

9 As in Tamura (2006), Murphy, Simon and Tamura (2008), Tamura and Simon (2015), we use a combination of infant mortality and young adult mortality so that mortality risk is given by

$$\delta_{iRt} = \frac{m_{iRt}}{3} + prob(\text{dying between ages of 1 and 35 years}|i, R, t).$$

10 This technology is a modification of Tamura (1991, 1996, 2006) and Tamura, Dwyer, Devereux and Baier (2014).

11 This parametric form, and the magnitudes chosen for ρ_t are broadly consistent with the literature on the intergenerational elasticity of earnings between parents and their progeny. For more, see references contained in Table 3 of Tamura, Dwyer, Devereux and Baier (2014). Furthermore, the upper rate of convergence, 1.7% per year is consistent with the evidence contained in Tamura (1996, 2001) and Barro & Sala-i-Martin (1991,1992) and many others.

12 The Baby Boom, which coincided with widespread suburbanization, is modeled as resulting from a decline in the price of living space. See Murphy, Simon and Tamura (2008) and Simon and Tamura (2009) for application to the US, and Tamura and Simon (2015) for application to an international cross section. Dettling and Kearney (2014) argue that rising house prices lead to declining fertility of renters but, via a wealth effect, rising fertility to homeowners. Alternative explanations of the Baby Boom abound, and were presented in the introduction. We view the declining price of space mechanism as complementary to other explanations. We leave it to future research to quantify the relative importance of all the varying methods of producing a Baby Boom. What is novel about this paper and Tamura and Simon (2015) is that it provides the only explanation of the rise in schooling of Baby Boom children.

13 Heckman and Payner (1989) and Holzer and Ihlanfeldt (1998) document discrimination in the labor market and Collins and Margo (2000, 2001, 2003) provide evidence for the housing market.

14 Murphy, Simon and Tamura (2008) used this formulation to fit fertility and schooling for the US, but their data were not separated out by race. Tamura and Simon (2015) fit the same two variables in an international cross-section. We recognize that richer models are possible. For example, Canaday and Tamura (2009) develop a model of black schooling in the Reconstruction and Jim Crow eras, in towns and plantations, rich in institutional detail, with discriminatory taxation as well as endogenous determination of school quality in the form of class size. Their model also permitted a limited form of migration, ignored here. However, they were interested only in the state of South Carolina, whereas we are interested in fitting data for all US states.

15 As mentioned previously, households are assumed to have perfect foresight about the values of ρ_t, but are not assumed to internalize the effect of their choice of schooling time on ρ_t.

16 Equation (12) is, however, homogeneous of degree φ in (h_t, h_{t+1}), a fact that proves useful in calculating approximate compensating and equivalent variations. In particular, for very low values of τ_t, then $\rho_t \approx 0$, and (12) is homogeneous of degree φ in h_t.

17 The numerical solutions allow for the possibility that fertility is at a corner as in Ehrlich and Lui (1991). In practice, all of our solutions for the choice variables produced interior solutions.

18 In 2000, the average white schooling, weighting by white population, is 14.9, and average black schooling, weighting by black population, is 14.3. The range of average white schooling in 2000 across the nine census divisions is very tight. The minimum is 14.7 (West South Central), and the maximum is 15.0 in the South Atlantic and Mountain divisions. The range of average black schooling in 2000 across the nine census divisions is also very small. The minimum average of 14.2 years occurs in the Middle Atlantic, West South Central, Pacific, and East North Central divisions. The highest average of 14.6 years occurs in the Mountain division. Furthermore in 2010 expected years of schooling equals or exceeds 14.90 years in Denmark, Finland, Iceland, New Zealand, and South Korea, see Tamura, Dwyer, Devereux and Baier (2014).

19 In our solutions, the balanced growth rate is given by $\ln(A\overline{\tau}^{\mu})/20$.

20 To see this, use (11) for expenditures on space or housing, but divide by actual measured income, $h_t[1 - x_t\theta] = h_t(1 - \theta)$.

21 Our calculations assume that the PDV of a high school graduate career is equal to the PDV of the Associate Degree worker. Each worker works until age 68 years. We assumed that tuition and fees averaged $10,000 per year and it takes four years to produce the equivalent of 3.25 years of additional schooling to obtain the AA degree. Our forgone earnings cost is of course sensitive to the interest rate chosen. Our $10,000 tuition and fees figure is perhaps a bit high. Net tuition and fees for 2013–2014 were $12,400 for private non profit colleges, $3120 for public four year colleges, and $-1550 for two year public colleges.

22 Only black schooling has a significant intercept.

23 We report the average absolute deviation from 1 instead of the average slope coefficient in order to avoid the possibility of an average close to 1, but in which no estimated slope coefficient is close to 1. The average root mean square deviation from 1 is 0.072.

24 The average root mean square of the intercept is 0.058.

25 The improvement in access of blacks to schooling was far from smooth. For example, Jim Crow laws impeded black progress, albeit with diminishing effects as early as 1920, c.f. Canaday and Tamura (2009).

26 Our calibration permits the preference parameters β_{it} and ν_{it} to vary by race, across states, and over time. Except for the limiting case of zero mortality risk, preferences of whites and blacks differ due to differences in the β and ν terms in the precautionary component. Otherwise the compensating variation and equilibrating variation would be similar except for income differences and the minimum fertility value, a.

27 Strictly speaking, this homogeneity holds only in the case of zero human capital spillovers, i.e. $\rho_t = 0$.

28 The full results are contained in Tables 23 and 24.

29 The range of Δ_t^b across regions under nation preferences is 0.19 in the West North Central to 4.8 in the East South Central. The range of Δ_t^b across regions under division preferences is 0.18 in the West North Central to 5.1 in the East South Central. So the ranges are also robust to aggregation.

30 Over Reconstruction the corresponding values using nation and division preferences are 3.3 to 3.0, respectively, c.f. Tables 23 and 24.

31 The welfare costs under nation preferences yield a welfare cost decline from 3.3 to 0.9, and with division preferences show a similar decline from 3.0 to 1.1, again c.f. Tables 23 and 24.

32 The picture is similar using division nation preferences or division preferences. Δ_t^b is 0.03 and 0.01, respectively, c.f. Tables 23 and 24. So our results are robust to aggregation.

33 Tables 23 and 24 present the same four welfare measures but using nation preferences and division preferences, respectively. These welfare measures present very similar results. Our results are robust to preference aggregation. Table 25 presents the correlations of all the welfare measures. Recall that typically $\Omega^i < 0$ and $\Delta^i > 0$, so the negative correlations in the table are expected. The average correlation is about $\frac{3}{4}$.

34 Although reductions in κ^b exert a wealth effect as well as substitution effect, our calibration shows parents choosing to invest more in each of a smaller number of children.

35 This effect is bounded at $\tau = 0.38125$. At this value of schooling, rising levels of schooling does not affect ρ. For all values of $\tau < 0.38125$, or schooling less than 15.25 years, lower discrimination leads to additional schooling and increases the utility gains of schooling as well.

36 This effect is much like the Mincer return to more years of schooling.

37 Figure 19 presents the EV_κ^b and CV_κ^w by census division, and Figure 20 presents the EV_κ^w and CV_κ^b by census divisions. The EV_κ^b and CV_κ^w averages use black population weights, and are expressed in terms of black lifetime wealth. The EV_κ^w and CV_κ^b are expressed relative to their own human capital. The averages are from white population and black population weights, respectively. In order to reduce clutter, we only present the results for the state preference model. Clearly, the most discriminatory regimes were the former Confederate slave states of the South Atlantic, East, and West South Central divisions.

38 The estimate of $95 trillion is sensitive to the interest rate chosen. This gain was partially offset by rising medical expenditures of $34 trillion for a net gain of $61 trillion, or roughly 125% of national wealth. We focus on the gross welfare gain because our exercise will not account for expenditures on health.

39 Table 11 presents the young adult mortality by period, race and census division. Young adult mortality is given by one third the infant mortality plus the probability of dying between the ages of 1 to 35 years.

40 Figures 21 and 22 present the welfare measures from state preferences by race and census division. As with the welfare estimates for differential schooling access, we find that the results from the state preferences are robust to preference aggregation, c.f. Tables 26 and 27.

41 See Tables 26 and 27 for the similar results for welfare measures using nation preferences and division preferences, respectively.

42 Unlike previous tables, all values in Table 13 are relative to own wealth, thus EV^w is measured relative to white wealth.

43 Perhaps, the small sample size of blacks in both North and South Dakota can induce these extremes. Ignoring the Dakotas produces a range of 27% in California and almost 300% in Texas.

44 Human capital in our model accumulates across generations, but remains constant over the life cycle. See Tamura, Dwyer, Devereux and Baier (2014) for a model that allows human capital acquisition over the life-cycle.

45 In the Appendix, we report in Table 28 the results under the assumption that ϵ_{it} is AR(1), and thus use a Prais-Winsten correction, and robust standard errors. The results are quite similar to those reported in the paper.

46 Results were similar when we estimated using weighted regression (log population weights) and/or including year dummies.

47 We only used males, and full time workers by restricting to those with at least 40 weeks of work and at least 35 hours worked per week.

48 For 2010, we used CPS data for years 2001–2009 in order to construct average earnings by age category. For example, to create the average black earnings of 26–35 year old males we constructed average earnings of black full time employed males between the ages of 26–35 years in 2001, and then 2002, all the way to 2009, weighting each by the number of black males in the age category in each year.

49 Our estimates suggest that there is a higher return on white human capital than to black human capital. There are many possible sources of this difference. One is measurement error; cell sizes for blacks are in some cases very low, generating measurement error in both the dependent and independent variable. Both types of error reduce precision, and the latter biases the estimated coefficient on human capital toward zero. We leave further investigation of this difference for future research.

50 As with the log level regressions in the top panel, all equations were estimated using fixed effects and with errors clustered at the state level.

51 Table 15 contains the time series of division relative human capital of blacks from 1800–2020. The final two years, 2010 and 2020 arise because the model produces the human capital of the next generation, born in 1990 and 2000 that will be adults in 2010 and 2020.

52 For whites, we actually get reverse discrimination results comparable to about 16% of black lifetime wealth.

53 In Haines' work in Table Ab1– 10 of the *Historical Statistics of the United States* reports, the US black infant mortality in 1850 to be 0.340.

54 Without Pennsylvania, the average $\overline{R}^2$ is 0.9661 and the standard deviation of $\overline{R}^2$ is 0.017.

55 These are Maine, Minnesota, and Montana.

56 In addition to the three M states above, New Hampshire and Vermont.

57 There are two exceptions in the case for whites. In 1880, even placing a 0 weight on the typically lower infant mortality figure from the Census, we cannot exactly fit Haines estimate of white infant mortality. Our figure of 190.4 per thousand white births is less than the 214.8 value reported by Haines.

In 1900, we are tad bit high, because we are now using some death registration values instead of back projected values.

58 If we multiplied our estimates by 2, and the probability of surviving to age 45 years, conditional on surviving to age 15 years, we would get smaller numbers. For 1820, this would mean multiplying by 0.826. Our corresponding average black fertility would then be: 5.65, which seems small relative to our 1830–1840 estimates, and Haines' 1850 estimate.

59 If we multiplied our estimates by 3, and the probability of surviving to age 45 years, conditional on surviving to age 15 years, we would get larger numbers. For 1830–1840, these multiples would be 1.247, and 1.269, respectively. Our corresponding average black fertility would then be: 9.56, 9.01. However, If only 90% of black women married, then the corresponding black fertility numbers would be 8.60, 8.11. If female mortality was higher than male mortality during child bearing years, we could justify multiplying by 0.9, which would bring us back to where we started!

60 If we multiplied our estimates by 3, and the probability of surviving to age 45 years, conditional on surviving to age 15 years, we would get larger numbers, basically twice as large. As can be seen from Table 1, our estimates for white fertility from 1800–1840 are already higher than the corresponding estimate from Haines, so multiplying by 2 would make the gap even larger.

61 If we average the error rates by year, weighting the percent error rates by the race share of the population, our national time series error rates is: −2.0%, −1.4%, 2.4%, and 3.4%, respectively. The simple average error rate is 0.6%.

62 For each census division, we compute the race population weighted average of state specific (β_{iRt}, ν_{iRt}) as division, D, race, and year preferences.

63 For the country, we compute the race population weighted average of state specific (β_{iRt}, ν_{iRt}) as race and year preferences.

64 We graph the preference parameters in Figures 28–31.

65 The careful reader will note that in the final two columns 1950 is contained in both samples. This is due to the fact that 1950 is the nadir of fertility before the Baby Boom, recall that fertility is defined as children ever born to women 35–44. Thus, women in 1950 aged 35–44 years were born between 1906–1915. They grew up during the Great Depression, and their fertility was probably completed by 1945, just before the Baby Boom begins.

66 Only the 1960–2000 period produces occasional disagreement, where Ω^b is of different sign than Ω^w and Δ^b is of opposite sign of Δ^w.

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