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Changing Current Net Nutrition with Weight as a Measure of Net Nutritional Change with the Transition from Bound to Free Labor: A Difference-in-Decompositions Approach

Abstract

A population's weight conditioned on height reflects its current net nutrition and demonstrates health variation during economic development. This study builds on the use of weight as a measure for current net nutrition and uses a difference-in-decompositions technique to illustrate how black and white current net nutrition varied with the transition to free-labor. Adult black age-related weight gain was greater with the transition to free-labor yet was not as large as the adult white age related weight gain. Agricultural worker's current net nutrition was better than workers in other occupations, and agricultural workers' net nutrition was better than workers in other occupations but was worse-off with the transition to free labor. Nativity had the greatest effect with weight changes and the transition to free-labor. Within-group weight variation was greater than across-group variation.

JEL-Codes: C100, C400, D100, I100, N300.

Keywords: weight variation, current net nutrition, Oaxaca decomposition.

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1. Introduction

When traditional measures for economic welfare are scarce or unreliable, stature and the body mass index (BMI) are now well accepted measures that reflect net nutrition during economic development (Fogel, 1994; Deaton, 2008; Case and Paxson, 2008; Deaton, 2013). A population's average stature reflects the cumulative net difference between calories consumed and calories required for work and to withstand the physical environment. BMI is weight in kilograms divided by height in meters squared, and changes in BMI may reflect variation in current net nutrition (Fogel, 1994, p. 375). In both historic and modern samples, BMIs are also used to classify obesity at a point in time. However, because it does not distinguish between sinew, muscle, and fat, BMI is only a crude approximation for obesity (Burkhauser and Cawley, 2008, pp. 519-520). Moreover, interpreting BMI variation is more problematic than interpreting stature variation because BMI variation depends on when privation occurs. For example, a child deprived of nutrition is less likely to reach their genetically pre-determined adult stature, their weight is distributed over smaller physical dimensions, and shorter individuals are more likely to be obese in later-life. Alternatively, well-fed individuals grow to taller statures, have greater physical space to distribute weight, and have lower adult BMIs (Carson, 2009a; Carson, 2012a; Komlos and Carson, 2017).

Weights after controlling for height is similar to BMI but does not suffer from this lagged effect of privation, therefore, also reflects variation in current net nutrition. Weight is more

plastic and responsive to the immediate effects of privation than BMI and height, and varies with the type of calories consumed (Riera-Chrichton and Tefft, 2014). A population's average weight varies when there is an imbalance between calories consumed, physical activity, and the physical environment. On its surface, holding current net nutrition constant, there is a positive relationship between stature and weight because taller statures require body mass, indicating that weight alone is not the only measure that isolates variation in current net nutrition because it depends on height (Carson, 2013b; Carson, 2016a; Carson, 2018a). To isolate how net nutrition varied with economic conditions, this study uses weight after controlling for height, demographic characteristics, and socioeconomic status to illustrate how weights varied with the transition from bound to free-labor (Carson, 2018b).

In the United States, the pace of dietary change and economic development reflects institutional change. During the antebellum period, whites with higher socioeconomic status lived off the expropriated output of enslaved blacks. From its beginning, US economic arrangements were based on inequality, and whites were at an institutionalized advantage to blacks (Steckel, 1979; Carson, 2015c). This material inequality may have extended to nutrition; nonetheless, slaves were more physically active and required more calories per day to maintain health (Fogel, 1974, p. 112; Carson, 2014b, p. 772). Aside from the Civil War itself, the greatest race conflagration during US economic development was the 1863 Manhattan race riots when lower socioeconomic status whites—many of them poor Irish immigrants—refused to fight to free former slaves because former slaves were perceived as competing with whites for unskilled occupations (Chernow, 2017, p. 298). Arnold Plant (1947, pp. 3-16), C. Vann Woodward (1951, p. 134), and Keith Tribe (2009, pp. 88 and 92) propose that lower socioeconomic status whites in US labor markets were made worse-off when they had to compete with free-blacks after the

transition to free-labor (Donald, 1995, p. 24). Alternatively, if whites acquired and demonstrated a taste for discrimination, blacks did not make significant progress in the immediate aftermath of the transition to free-labor (Becker, 1957, pp. 75-80; Becker, 1966, pp. 188-190; Higgs, 1977, pp. 8-10). Subsequently, if white workers' taste for discrimination increased with the transition to free-labor, lower socio-economic status white weights would have increased relative to blacks with the transition to free-labor.

It is against this backdrop that this study uses black and white weight as a proxy for net nutrition and the transition to free-labor. Three questions are considered. First, a weight difference-in-decompositions is used to isolate black and white weight variation between bound and free-labor and how sources of weight variation sources changed with the transition. White relative to black weight increased with the transition to free labor, and white within-group socio-economic status weight returns increased with the transition. Second, how did black and white youth and adult weights vary by age with the transition to free-labor? Adult black age-related weight gain was greater with the transition to free-labor yet was not as large as the adult white age related weight gain. Third, what were the greatest sources of black-white weight variation with the transition to free-labor? Nativity had the greatest effect with weight changes and the transition to free-labor, and after controlling for height, black weights were greater under bound-labor.

2. Materials and Methods

Given its importance relative to other physical measures, weight has received little attention in historical health studies. Komlos (1987, p. 906) and Coclanis and Komlos (1995) show that the decrease in 19th century weight and heights was geographically widespread, and

farmer's weights were greater than workers in other occupations. Student weights at The Citadel decreased between the 1880s and 1900s and the South Atlantic was among the poorest geographic regions in the 1880s and 1890s (Coclanis and Komlos, 1995, pp. 104-106).[1] However, these studies are for military recruits, which are exclusive to whites (Sokoloff and Vilaflour, 1982, pp. 456-458; Komlos, 1987; Coclanis and Komlos, 1995, p. 93; Ellis, 2004, p. 27). Carson (2015a) and Carson (2017) use late 19th and early 20th century US prison records to show this weight pattern extended to lower socioeconomic status whites and blacks. Farmers had greater weight than workers in other occupations, and height varied across regions. Individuals residing in the South and West had greater weights than individuals living elsewhere.

Data to assess late 19th and early 20th century weight variation reflects an extensive effort to collect, collate, and examine net nutrition and health during US economic development. Each state prison archive was contacted on multiple occasions, and available and affordable records were acquired and entered into a master data set. While not all prisons recorded both weight and height, the majority did, and Arizona, Colorado, Idaho, Illinois, Kentucky, Missouri, Montana, Nebraska, New Mexico, Oregon, Pennsylvania, Philadelphia, Tennessee, and Texas prison records are used here to evaluate how weight varied with the US transition from bound to free-labor.[2] At the time of incarceration, prison enumerators recorded a broad set of individual characteristics, which includes weight, height, race, age, nativity, occupations, and reception

[1] Costa (1993) was an early weight study but her objective is the relationship between BMI and mortality risk.

[2] All prisons were contacted on multiple occasions, and available and affordable records were entered into a master data set. These records include Arizona, Colorado, California, Idaho, Illinois, Kentucky, Maryland, Montana, Mississippi, Montana, Nebraska, New Mexico, Ohio, Oregon, Pennsylvania, Philadelphia, Tennessee, Texas, Utah, and Washington.

date. Each individual's weight and height were recorded as a means of identification within prisons and were used for identification in case they escaped and were recaptured.

Military and prison records are the primary sources for historical weight and height data. Military records provide the largest source of recorded heights; however, because military participation likely reflects conditions among the upper class, military weight records probably reflects current net nutrition among higher socioeconomic groups (Sokoloff and Vilaflor, 1982; Ellis, 2004, p. 27). Fortunately, prison records avoid many biases inherent in military records; nevertheless, prison records are not above scrutiny. Moreover, 19th century military service rigidly excluded blacks, whereas prison records included a higher share of African-Americans. Because this study considers only male statures during the transition from bound to free labor, women are excluded from the analysis but are considered elsewhere (Carson, 2011; Carson, 2013; Carson, 2018a). Consequently, prison records are more likely to reflect biological conditions among the working class, however, also includes information among skilled workers and African-Americans.

At the time of incarceration, an individual's complexion was recorded by prison enumerators and used to identify individuals in prisons. Complexions for individuals of African descent were recorded as Negro, black, dark black, and light black (Carson, 2015b). The complexion of individuals of European descent were recorded as light, medium, dark, and white. This European classification scheme is further supported by European-born immigrants in US prisons who were also recorded as light, medium, dark, and white. In both the US population census and prison records, until the 1930s, it was standard to refer to individuals of mixed European and African descent as 'mulatto,' but are referenced here as mixed-race. Because

individuals of African and European descent were most affected by the transition to free-labor, only US-born blacks and whites are considered in this study.

Occupation is a reasonable measure to assess how physical conditions varied by socioeconomic status. Occupations were recorded at the time an individual was admitted to prison, and reflect pre-incarceration conditions, not conditions within prisons. Occupations are classified into seven broad categories: no-occupations, common unskilled, farm laborers, farmers, ranchers, skilled, and white-collar workers. Common unskilled workers were recorded as teamsters, railroaders, and painters and were more likely to come to maturity in urban areas, where access to nutrition was limited and virulent disease environments more common (McGuire and Coelho, 2011, pp. 52-53). On the other hand, farm laborers were more likely to reach maturity in rural environments where there was easy-access to nutrition and mild disease environments. The distinction is important because combining common and farm laborers over estimates the biological benefits of being a common unskilled worker and underestimates the benefits of being a farm laborer. General farmers and dairymen are recorded as farmers, while

ranchers and stockmen are recorded as ranchers. Blacksmiths, tailors, and stonecutters are recorded as skilled workers, while physicians, the clergy, and bankers are recorded as white-collar workers.[3]

[3] There is some concern regarding how prison unskilled workers compared to the general population. As expected, the percent of unskilled workers in the prison sample is greater than the percent in the general population, indicating the prison population represents conditions among the working class.

Year	*US Population*	*Prisoners*
1850s		32.9
1860s		58.2
1870s	31.9	52.6
1880s	30.4	47.5
1890s		52.0
1900s	33.1	52.3
1910s	29.5	46.9
1920s	23.6	37.8

Source: US general population estimates are from Rosenbloom, 2002, p. 88.

Table 1, Average Black and White Characteristics between Bound and Free Labor

	Black, Bound		*Black, Free*		*White, Bound*		*White, Free*	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Age	31.31	11.69	24.31	6.78	34.86	12.33	26.94	7.60
Nativity	*N*	*Percent*	*N*	*Percent*	*N*	*Percent*	*N*	*Percent*
Northeast	66	.30	130	.26	903	2.87	1,177	1.74
Middle Atlantic	1,659	7.45	2,087	4.15	11,180	35.58	10,694	15.81
Great Lakes	360	1.62	1,554	3.09	3,848	12.25	11,987	17.72
Plains	702	3.15	5,117	10.19	2,141	6.81	16,858	24.93
Southeast	14,716	66.08	25,065	49.90	10,366	32.99	14,455	21.37
Southwest	4,729	21.24	15,962	31.78	2,242	7.13	8,287	12.25
Far West	37	.17	317	.63	744	2.37	4,176	6.17
Occupations								
White-Collar	636	2.86	1,542	3.07	3,165	10.07	8,658	12.80
Skilled	1,890	8.49	4,877	9.71	7,329	23.32	15,849	13.43
Farmer	1,601	7.19	5,344	10.64	2,386	7.59	8,262	12.22
Rancher	6	.03	26	.05	147	.47	886	1.31
Farm Laborer	45	.20	84	.17	187	.60	455	.67
Unskilled	11,836	53.15	28,924	57.58	13,011	41.40	29,329	43.36
No Occupation	6,255	28.09	9,435	18.78	5,199	16.54	4,195	6.20
Ages								
Teens	2,303	1034	12,701	25.28	2,061	6.56	9,124	13.49
20s	10,188	45.75	28,288	56.31	20,946	34.83	38,250	56.55
30s	4,703	21.12	7,356	14.64	7,993	25.44	15,237	22.53
40s	2,829	12.70	1,716	3.42	5,722	18.21	4,249	6.28
50s	1,651	7.41	159	.32	3,472	11.05	679	1.00
60s	595	2.67	12	.02	1,230	3.91	95	.14
Total	22,269		50,232		31,424		67,634	

Source: Arizona State Library, Archives and Public Records, 1700 W. Washington, Phoenix, AZ 85007; Colorado State Archives, 1313 Sherman Street, Room 120, Denver, CO 80203; Idaho State Archives, 2205 Old Penitentiary Road, Boise, Idaho 83712; Illinois State Archives, Margaret Cross Norton Building, Capital Complex, Springfield, IL 62756; Kentucky Department for Libraries and Archives, 300 Coffee Tree Road, Frankfort, KY 40602; Missouri State Archives, 600 West Main Street, Jefferson City, MO 65102; William F. Winter Archives and History Building, 200 North St., Jackson, MS 39201; Montana State Archives, 225 North Roberts, Helena, MT, 59620; Nebraska State Historical Society, 1500 R Street, Lincoln, Nebraska, 68501; New Mexico State Records and Archives, 1205 Camino Carlos Rey, Santa Fe, NM 87507; Oregon State Archives, 800 Summer Street, Salem, OR 97310; Pennsylvania Historical and Museum Commission, 350 North Street, Harrisburg, PA 17120; Philadelphia City Archives, 3101 Market Street, Philadelphia, PA 19104; Tennessee State Library and Archives, 403 7th Avenue North,

Nashville, TN 37243; Texas State Library and Archives Commission, 1201 Brazos St., Austin TX 78701; Utah State Archives, 346 South Rio Grande Street, Salt Lake City, UT 84101; Washington State Archives, 1129 Washington Street Southeast, Olympia, WA 98504.

Four categories are used to evaluate the transition to free-labor: blacks and whites born before 1866, and blacks and whites born after 1865. Table 1 presents descriptive statistics for each category. Birth decades begin as early as the 1730s and continued through the 1920s. Reception dates began in 1803 and lasted through the 1940s. For births before 1866, most blacks were native to the south, while most whites were native to the Middle-Atlantic, Southeast, and Great Plains. While unskilled labor was the most common occupation, there were considerably more white skilled workers, and whites were about five times more likely than blacks to be white-collar and skilled workers. For birth before 1866, there was about the same proportion that reported their occupation as farmers. Black and white farmers were unlikely to be incarcerated; however, whites were more likely to be farmers before and after the transition to free-labor. As is common today, historical crimes were committed by the young (Hirschi and Gottfredson 1983; Gottfredson and Hirschi, 1990; Freeman, 1999, p. 353; Carson, 2009c), and over half of young black males born under bound labor were in their teens and twenties. While the majority of whites were incarcerated in their 20s, proportionally more whites were in their thirties, forties, and fifties than in their teens. Although the proportion in the Southwest increased with westward expansion, black nativity under free-labor remained mostly in the South. White nativity remained from the North, but Plains, Southwest, and Far West nativity increased with free-labor.

In health studies, weight can be measured by observation or birth period. Measured from birth period, weight summarizes the cumulative net nutrition as a cohort ages over time because birth cohorts experience similar social, economic, and technological events throughout life. By

contrast, weight by observation period summarizes the current net nutrition experienced by different cohorts at a point in time. Moreover, because weight is positively related to height, measuring weight by birth sheds light on net nutrition during the transition to free-labor. Results examined here are by birth cohorts, therefore, summarize cumulative net nutrition since birth during the transition to free labor.

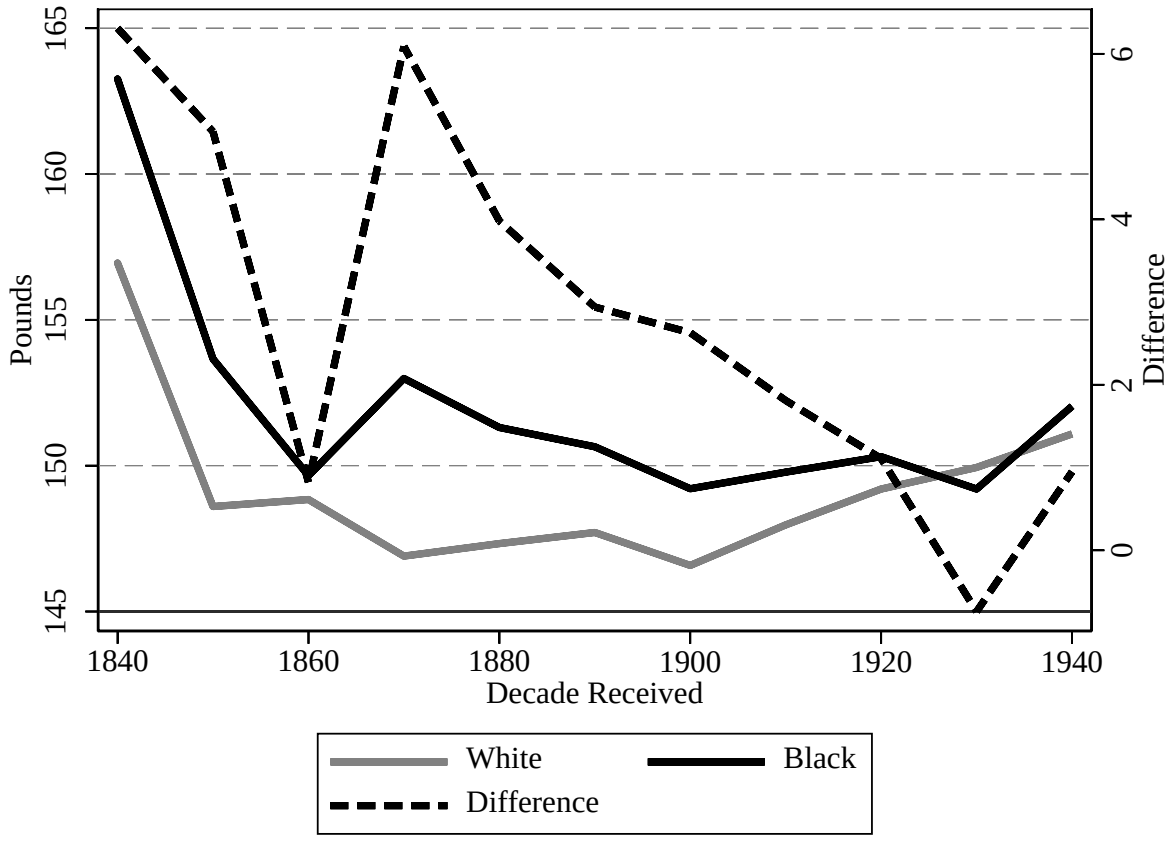

Figure 1, Late 19th and Early 20th Century Weight Variation by Birth over Time

Source: See Table 1.

Figure 1 plots black and white average weights between 1840 and 1940 by observation decade. Black weights were greater than white weights (Carson, 2015b), and black and white

greatest average weight difference was during the early 19th century. There was a small antebellum weight difference in 1860, which was followed immediately in 1870 by the largest weight difference. Given weight variation in Figure 1 and 19th century political events, the most reasonable period to partition weight is in 1865 around the time of emancipation.

3. Econometric Model

A Blinder-Oaxaca decomposition is a statistical technique that isolates differences between dependent variables that are due to structural and composition effects (Blinder, 1973; Oaxaca, 1973; Schneewiess, 2011). To isolate causal effects, a difference-in-difference estimator is a widely used method the quasi-experimental literature (Card and Krueger, 1993). These two methods are combined here to to separate and distinguish between black and white weight differences by returns and average characteristics associated with the transition to free-labor. A difference-in-decompositions is constructed to determine how black and white weights varied across and within groups with the transition to free labor. If there are large differences between characteristic returns associated with dependent variable differences before and after an event but small differences associated with average characteristics, greater causal interpretation is attributable to characteristics. If, on the other hand, there is little difference between characteristic returns and large differences between average characteristics, differences are associated with sample compositions.

3.1 Model

Let the control and treatment response variables w_c and w_t be expressed as

$$w_c = \alpha_{0c} + \beta_{1c}\overline{X}_c \qquad (1)$$

and

$$w_t = \alpha_{0t} + \beta_{1t}\overline{X}_t \qquad (2)$$

A Oaxaca decomposition is the difference between treatment and control response variables.

$$\Delta w = w_t - w_c = \alpha_{0t} + \beta_{1t}\overline{X}_t - \alpha_{0c} - \beta_{1c}\overline{X}_c \qquad (3)$$

The counter-factual is obtained by adding and subtracting $\beta_{1t}\overline{X}_c$ to the right hand-side and collecting like terms.

$$\Delta w = w_t - w_c = (\alpha_{0t} - \alpha_{0c}) + (\beta_{1t} - \beta_{1c})\overline{X}_c + (\overline{X}_t - \overline{X}_c)\beta_{1t} \qquad (4)$$

where α_{0c} and α_{0t} are the autonomous weight components for control and treatment groups. β_{1c} and β_{1t} are coefficients for weight control and treatment characteristic returns (Carson, 2010; Carson, 2011b; Carson and Hodges, 2014). $\overline{X}_c$ and $\overline{X}_t$ are control and treatment group average characteristic matrices.

Let white and black bound and free-labor weights be expressed in vectors.

$$w_b^{bound} = \alpha_b^{bound} + \beta_b^{bound}\overline{X}_b^{bound} \qquad (5)$$

$$w_w^{bound} = \alpha_w^{bound} + \beta_w^{bound}\overline{X}_w^{bound} \qquad (6)$$

$$w_b^{free} = \alpha_b^{free} + \beta_b^{free}\overline{X}_b^{free} \qquad (7)$$

$$w_w^{free} = \alpha_w^{free} + \beta_w^{free}\overline{X}_w^{free} \qquad (8)$$

where w_b^{bound} is African-American weight for individuals born before 1866, and w_b^{free} are black weights born after 1865. w_w^{bound} and w_w^{free} are defined similarly for whites. a_b^{bound} and a_b^{free} are the intercepts for black males born before and after 1865; a_w^{bound} and a_w^{free} are defined for whites in like

fashion. β_w^{bound} and β_b^{bound} are the white and black bound-labor control group weight characteristics. β_w^{free} and β_b^{free} are defined similarly for the post transition white and black weight returns. $\overline{X}_b^{bound}$ and $\overline{X}_b^{free}$ are black average bound and free-labor characteristic matrices. $\overline{X}_w^{bound}$ and $\overline{X}_w^{free}$ are white male characteristics before and after 1865.

There are two ways to compare the effects between ethnic groups: across-group and within-group. The across-group decomposition isolates the black-white weight difference between bound and free-labor and how it varied with the transition to free-labor. The within-group weight decomposition isolates within-group weight differences before and after the transition to free-labor. It is also noteworthy that, unlike a difference-in-difference estimator, the decomposition order varies between across and within difference-in-decompositions because differences-in-decompositions are first decomposed and the decompositions are differenced, yielding differences between across and within group decompositions that are different from a differences-in-differences estimator (Wooldridge, 2016, p. 410). The black-white across-group difference-in-decompositions is considered first, followed by the within-group decomposition. Like event studies, difference-in-decompositions address the causal effect on an event. However, difference-in-decompositions isolate how dependent variable different sources varied with an event.

3.2 Across-groups Decomposition

The across-group decomposition identifies black and white weight differences across racial groups attributable to returns to characteristics and average characteristics with the transition to free-labor. To start, the across-group difference-in-decompositions is calculated by taking the black and white weight decompositions under free and bound-labor. Because blacks

had greater weights, they are assigned as the base structure (Carson, 2012b; Carson, 2015b; Carson, 2017; Carson, 2018a).

$$\Delta w^{free} = \left(\alpha_b^{free} - \alpha_w^{free}\right) + \left(\left(\beta_b^{free} - \beta_w^{free}\right)\overline{X}_b^{free}\right) + \left(\left(\overline{X}_b^{free} - \overline{X}_w^{free}\right)\beta_w^{free}\right) \quad (9)$$

$$\Delta w^{bound} = \left(\alpha_b^{bound} - \alpha_w^{bound}\right) + \left(\left(\beta_b^{bound} - \beta_w^{bound}\right)\overline{X}_b^{bound}\right) + \left(\left(\overline{X}_b^{bound} - \overline{X}_w^{bound}\right)\beta_w^{bound}\right) \quad (10)$$

The across-group difference-in-decomposition is then calculated by taking the difference between Equations 9 and 10.

$$\Delta w_{\Delta} = \Delta w^{free} - w^{bound} = \left(\alpha_b^{free} - \alpha_w^{free}\right) + \left(\left(\beta_b^{free} - \beta_w^{free}\right)\overline{X}_b^{free}\right) + \left(\left(\overline{X}_b^{free} - \overline{X}_w^{free}\right)\beta_w^{free}\right)$$

$$- \left(\alpha_b^{bound} - \alpha_w^{bound}\right) - \left(\left(\beta_b^{bound} - \beta_w^{bound}\right)\overline{X}_b^{bound}\right) - \left(\left(\overline{X}_b^{bound} - \overline{X}_w^{bound}\right)\beta_w^{bound}\right) \quad (11)$$

which is re-arranged as

$$\Delta w_{\Delta} = \Delta w^{free} - \Delta w^{bound} = \left(\alpha_b^{free} - \alpha_w^{free}\right) - \left(\alpha_b^{bound} - \alpha_w^{bound}\right) + \left(\left(\beta_b^{free} - \beta_w^{free}\right)\overline{X}_b^{free}\right) - \left(\left(\beta_b^{bound} - \beta_w^{bound}\right)\overline{X}_b^{bound}\right)$$

$$+ \left(\left(\overline{X}_b^{free} - \overline{X}_w^{free}\right)\beta_w^{free}\right) - \left(\left(\overline{X}_b^{bound} - \overline{X}_w^{bound}\right)\beta_w^{bound}\right) \quad (12)$$

Equation 12 is the across-group weight difference-in-decompositions. The across-group difference-in-decompositions isolates across-group weight changes around the time of emancipation, but they also account for differences in across-group balance compositional effects.

3.3 Within Group Decomposition

There was also a black and white weight difference within-groups with the transition to free-labor that illustrates how weight returns varied within ethnic groups with the transition. The within-group decomposition is calculated by decomposing weights within racial groups after and

before bound-labor, and free-labor weights are assigned as the base structure. The within-group difference-in-decompositions is derived by first decomposing black and white weights between free and bound labor.

$$\Delta w_{Black} = \left(\alpha_b^{free} - \alpha_b^{bound}\right) + \left(\left(\beta_b^{free} - \beta_b^{bound}\right)\overline{X}_b^{bound}\right) + \left(\left(\overline{X}_b^{free} - \overline{X}_b^{bound}\right)\beta_b^{free}\right) \qquad (13)$$

$$\Delta w_{White} = \left(\alpha_w^{free} - \alpha_w^{bound}\right) + \left(\left(\beta_w^{free} - \beta_w^{bound}\right)\overline{X}_w^{bound}\right) + \left(\left(\overline{X}_w^{free} - \overline{X}_w^{bound}\right)\beta_w^{free}\right) \qquad (14)$$

The within group difference-in-decompositions is then derived by taking the difference between black and white free and bound-labor decompositions.

$$\Delta w_{\Delta} = \Delta w_{black} - \Delta w_{white} = \left(\alpha_b^{free} - \alpha_b^{bound}\right) + \left(\left(\beta_b^{free} - \beta_b^{bound}\right)\overline{X}_b^{bound}\right) + \left(\left(\overline{X}_b^{free} - \overline{X}_b^{bound}\right)\beta_b^{free}\right)$$
$$- \left(\alpha_w^{free} - \alpha_w^{bound}\right) - \left(\left(\beta_w^{free} - \beta_w^{bound}\right)\overline{X}_w^{bound}\right) - \left(\left(\overline{X}_w^{free} - \overline{X}_w^{bound}\right)\beta_w^{free}\right) \qquad (15)$$

which is arranged as

$$\Delta w_{\Delta} = \Delta w_{black} - \Delta w_{whitek} = \left(\alpha_b^{free} - \alpha_b^{bound}\right) - \left(\alpha_w^{free} - \alpha_w^{bound}\right) + \left(\beta_b^{free} - \beta_b^{bound}\right)\overline{X}_b^{bound} - \left(\beta_w^{free} - \beta_w^{bound}\right)\overline{X}_w^{bound} -$$
$$+ \left(\overline{X}_b^{free} - \overline{X}_b^{bound}\right)\beta_b^{free} - \left(\overline{X}_w^{free} - \overline{X}_w^{bound}\right)\beta_w^{free} \qquad (16)$$

Equation 16 is the black-white within-group difference-in-decompositions. The within-group difference-in-decompositions isolates weight differences related to within-group weight changes around the time of emancipation, but they also account for differences in within-group balance compositional effects.

4. Empirical Analysis

Table 2 presents bound and free-labor weight regressions by ethnic status. Model 1 presents black weight for individuals born before 1866, while Model 2 does the same for whites.

Model 3 presents the black weight model for individuals born after 1865, while Model 4 does the same for whites.

Table 2, Black and White Bound and Free Labor Weight Models by Demographics, Socioeconomic Status, and Nativity

	Model 1	*Model 2*	*Model 3*	*Model 4*
	Black, Bound	White, Bound	Black, Free	White, Free
Intercept	-34.37***	-45.26***	-32.87***	-44.00***
Height				
Inch	.603***	.658***	.607***	.651***
Ages				
12	-11.24***	-2.75***	-10.69***	-11.61***
13	-11.65***	-3.75***	-11.33***	-6.17***
14	-9.18***	-5.43***	-9.28***	-6.83***
15	-9.21***	-7.26***	-7.91***	-5.16***
16	-7.50***	-5.13***	-6.18***	-4.53***
17	-5.13***	-3.90***	-4.61***	-3.48***
18	-4.30***	-2.80***	-3.49***	-2.59***
19	-2.66***	-1.88***	-2.29***	-1.75***
20	-1.93***	-.804***	-1.31***	-1.05***
21	-.726***	-.706***	-.822***	-.752***
22	-.506***	-.501***	-.445***	-.489***
23-29	Reference	Reference	Reference	Reference
30s	.380***	.503***	.252***	.753***
40s	.176***	1.05***	.627***	1.88***
50s	.122***	1.46***	.929***	2.09***
60s	-.770***	1.01***	3.17***	2.66***
Occupations				
White-Collar	-1.04***	.711	-1.99***	-1.12***
Skilled	.067	.390*	-1.41***	-.860***
Farmer	.286	1.20***	-.250	-.081
Rancher	-1.02	2.59***	-.581	1.89***
Farm Laborer	.562	2.62	3.46*	3.20***
Unskilled	.331	.854***	-1.44***	-.784***
No Occupation	Reference	Reference	Reference	Reference
Nativity				

Northeast	Reference	Reference	Reference	Reference
Middle Atlantic	.045	-1.14***	-1.37*	-.230
Great Lakes	.960	-.413	-.977	-.058
Plains	1.67***	-1.06***	-1.52**	-.929***
Southeast	2.14***	-1.06***	-.443	-.859***
Southwest	1.57**	-2.40***	.206	-..429**
Far West	.600	.743**	-.570	.020
N	22,269	31,424	50,232	67,634
R^2	.3477	.2907	.4019	.3064

Notes: *** is significant at .01. ** is significant at .05. * is significant .10.

Source: Sees Table 1.

4.1 Bound Labor and the Antebellum Period

For blacks and whites across all periods, there was a remarkably stable relationship between weight and height. A well-known result in late 19th and early 20th century African-American youth stature studies is that slave children had shorter statures compared to their white counterparts (Steckel, 1986a; Steckel, 1986b; Steckel, 2016, p. 41). Steckel (1986a, pp. 732-733) illustrates that much of this disparity was attributable to fetal and infant growth restrictions, when neonate nutrition was restricted, and mother's diets transitioned away from proteins, calcium, and iron.[4] Until they approached entry into the adult slave labor force, slave masters were uncertain which children would survive to adulthood and were judicious when allocating plantation resources to youth nutrition, and slave children persistently had shorter statures compared to whites (Steckel, 1986a; Steckel, 1986b, Schneider, 2017, pp. 4-7; Komlos, 1992, p. 300; Carson, 2008b). Nothing is known, however, about how black youth weights varied by age and how their weights compared to white youth weights. During the antebellum period, black

[4] Schneider (2017, pp. 4-7) demonstrates that Steckel may overstate neonatal slave in-utero conditions.

youth weights were consistently lower than whites, though converged with adult black weights as black youths approached adulthood and entry into the adult labor force. Nonetheless, the black free-labor youth weight gain with age was similar to the black bound-labor youth weight gain with age, indicating the black youth weight gain may not be unique to the transition to free-labor (Komlos, 1992, p. 300; Carson, 2015b). At older ages, adult slave weight gain was lower than whites under bound-labor, extending a new pattern in black-white biological studies. Under the discretion of slave masters, antebellum adult black weight gain under free-labor was less than for whites.

Under bound-labor, there was little black weight variation by occupations, and masters allocated plantation nutrition to slaves just enough to keep slaves in sufficient health to withstand plantation labor but did not feed them to excess. To the degree that skilled and white-collar slaves were trained in skilled occupations (Fogel, 1974, pp. 41-43), unskilled field hands and common laborers did not receive excess net calories compared to workers in other occupations (Steckel, 2016, p. 42). On the other hand, under bound-labor, white ranchers, farmers, and farm laborers had greater weight returns than slaves and received above average calories relative to work effort. Antebellum current net nutrition varied regionally, and blacks in slave holding states had significantly greater weights compared to their white counterparts. However, slaves were located in the South, which was agriculturally more productive than other regions (Hilliard, 1972; Carson, 2014b). Under bound-labor, whites from the Northeast had greater weight returns than elsewhere within the US.

4.2 Free-labor and the Postbellum Period

Under free-labor, adult black age-related weight gain was higher than black returns during the antebellum period. However, black adult weight gain with age was lower than whites. Under free-labor, black and white skilled and white-collar worker weights were lower than workers in other occupations, and white agricultural worker's weights continued to be high. Moreover, unskilled black and white worker weights under free-labor were lower than unskilled workers under bound-labor, indicating that unskilled workers' net nutrition was likely higher with industrialization (Carson, 2008a; Carson, 2009b; Carson, 2014d). White weights during free-labor also varied by nativity, and black nativity demonstrated little regional variation under free-labor, whereas, there was a strong black nativity effect under bound labor in slave holding states. That there was little black free-labor weight variation by nativity but considerable bound-labor black weight variation indicates that without respect to slave occupations, slave-owners and overseers had greater incentives to allocate plantation nutrition to slaves independent of their occupations to maintain their investments in slave property. Alternatively, white free-labor weight in current or former slave holding states were lower than blacks but improved under free-labor.

5. Decomposing Black and White Weight for Bound and Free-Labor

Table 3's Panel A is the black-white free-labor across-group weight decomposition (Equation 9). Panel B is the black-white bound-labor across-group weight decomposition (Equation 10). Panel C is the weight difference-in-decompositions between Panels A and B and separates changes in the black-white across-group difference into returns to characteristics and average characteristics (Equation 12). Panel C's elements are positive if black weights were

greater than whites with the transition to free-labor, and negative if black weights were greater under bound-labor. Panel C's elements are percent differences between blacks and whites associated with the transition to free-labor.

Table 3, Weight Across Group Difference in Decompositions

Panel A	*Column 1*	*Column 2*	*Column 3*	*Column 4*
Free-Labor Decomposition	$\left(\beta_b^{free} - \beta_w^{free}\right)X_b^{fr}$	$\left(X_b^{free} - X_w^{free}\right)\beta_w^{free}$	$\left(\beta_b^{free} - \beta_w^{free}\right)X_w^{free}$	$\left(X_b^{free} - X_w^{free}\right)\beta_b^{free}$
	Column 1	*Column 2*	*Column 3*	*Column 4*
Levels				
Sum	3.01	-2.03	2.23	-1.25
Total		.980		.980
Proportions				
Intercept	11.36		11.36	
Height	-7.63	-.143	-7.73	-1.33
Ages	-.437	-.485	-.446	-.476
Occupations	-.490	-.004	-.539	.045
Nativity	.275	-.161	-.368	.482
Sum	3.08	-2.08	2.28	-1.28
Total		1		1
Panel B				
Bound-Labor Decomposition	$\left(\beta_b^{bound} - \beta_w^{bound}\right)X$	$\left(X_b^{bound} - X_w^{bound}\right)\beta_w^{b}$	$\left(\beta_b^{bound} - \beta_w^{bound}\right)X_w^{b}$	$\left(X_b^{bound} - X_w^{bound}\right)\beta_b^{b}$
	Column 1	*Column 2*	*Column 3*	*Column 4*
Levels				
Sum	3.64	-1.21	2.16	.265
Total		2.43		2.43
Proportions				
Intercept	4.48		4.48	
Height	-3.86	-.300	-3.89	-.274
Ages	.245	-.060	-.338	.033
Occupations	-.176	-.014	-.236	.045
Nativity	1.30	-.124	.869	.305
Sum	1.50	-.498	.891	.109
Total		1		1
Panel C				
Differences in Decompositions	Free minus Bound Labor		Free minus Bound Labor	
Levels				
Sum	-.624	-.825	.068	-1.52

Total		-1.45		-1.45
Proportions				
Intercept	6.87		6.87	
Height	-3.77	-1.13	-3.84	-1.06
Ages	-.193	-.425	-.109	-.509
Occupations	-.313	.010	-.304	4.51^{-4}
Nativity	-1.02	-.037	-1.24	.177
Sum	1.58	-1.58	1.39	-1.39

Source: See Table 1.

Notes: Standard errors clustered on age.

5.1 Across-Group Free-Labor Decomposition

Table 3's Panel A's positive intercept, 11.36 pounds, indicates that black weights were independently greater under free-labor, and black weights associated with unidentified characteristics were greater with the transition to free-labor. However, sources of the across-group free-labor decomposition were important. White weight returns associated with height were considerably greater under free-labor, and the difference in average sample heights was small, indicating white weight returns to height were large under free-labor. Although not as large, white free-labor age and socioeconomic status were also greater than blacks. Results are mixed for free-labor nativity the relationship between black and white weight returns. Measured at average black characteristics and white means, blacks had greater weight returns associated with nativity (Column 1); nonetheless, whites had a large off-setting effect associated with mean characteristics (Column 2). Measured at average white returns to characteristics and black average characteristics, whites had greater weight returns associated with nativity; however, black average weights offset the white returns advantage. The majority of greater black weights was due to returns to weight rather than compositional effects.

5.2 Across-Group Bound-Labor Decomposition

Table 3's Panel B's bound-labor decomposition illustrates that black relative to white weights were greater under bound-labor; however, the black autonomous weight component was larger under free labor (Table 3, Panel A). The black weight advantage was also associated with characteristics under bound-labor. The weight-age returns result is mixed for bound-labor. Measured at average black characteristics and white returns, blacks had greater weight returns associated with age (Column 1); however, whites had greater weight returns associated with average characteristics (Column 2). Measured at average white characteristics and black returns (Column 3), whites had greater weight returns associated with age; nevertheless, blacks had greater weight returns associated with average age (Column 4). Weight returns associated with socioeconomic status favored whites during bound-labor, when the institution was most entrenched. Black weight-nativity returns were greatest under bound-labor, when owners and slave masters had incentives to provide sufficient calories to maintain their slave property. The majority of greater bound-labor black weight was due to returns to characteristics rather than composition effects.

5.3 Across-Group Differences-in-Decompositions

Table 3's Panel C is the black-white across group's weight differences-in-decompositions and illustrates how net nutrition varied between blacks and whites with the transition to free-labor. The summer of 1863 race riots in lower Manhattan occurred when lower socioeconomic status whites were unwilling to fight to free African-Americans, and a common interpretation was that lower socioeconomic status whites were made worse-off with the end of slavery because slaves competed with unskilled whites (Plant, 1947; Woodward, 1951). However, rather

than being worse off with the transition to free-labor, the -1.45 level intercept difference indicates white's current net nutrition improved relative to blacks with the transition to free-labor, and the source of the advantage varied with the transition (Carson, 2018b). Notably, more of the black weight advantage was due to non-identifiable sources in the intercept under free-labor. While overall white stature and net nutrition was greater with the transition, the positive autonomous intercept indicates that black weights due to non-identified sources in the intercept increased with the transition to free-labor. However, black weight returns to height, age, occupation, and nativity were greater relative to whites under bound-labor, when slave masters and owners had vested interests to maintain investments in slave net nutrition, and it was bound-labor returns to characteristics that made black weights higher under bound-labor.

Table 4, Weight within Group Difference in Decompositions

Panel A	*Column 1*	*Column 2*	*Column 3*	*Column 4*
Black Decomposition	$\left(\beta_b^{free} - \beta_b^{bound}\right)X$	$\left(X_b^{free} - X_b^{bound}\right)\beta_b^{fre}$	$\left(\beta_b^{free} - \beta_b^{bound}\right)X_b^{free}$	$\left(X_b^{free} - X_b^{bound}\right)\beta_b^{bo}$
	Column 1	*Column 2*	*Column 3*	*Column 4*
Levels				
Sum	-.889	-1.32	-1.02	-1.18
Total		-2.21		-2.21
Proportions				
Intercept	-.680		-.680	
Height	-.310	.187	-.308	.185
Ages	-.134	.374	-.099	.339
Occupations	.513	.043	.566	-.011
Nativity	1.01	-.007	.986	.022
Sum	.403	.597	.465	.535
Total		1		1
Panel B				
White Decomposition	$\left(\beta_w^{free} - \beta_w^{bound}\right)X$	$\left(X_w^{free} - X_w^{bound}\right)\beta_w^{fre}$	$\left(\beta_w^{free} - \beta_w^{bound}\right)X_w^{free}$	$\left(X_w^{free} - X_w^{bound}\right)\beta_w^{bo}$
Levels				
Sum	.339	-.417	-.539	-.216
Total		-.756		-.756
Proportions				
Intercept	-1.67		-1.67	
Height	1.59	-.313	1.59	-.317
Ages	-.389	.871	-.272	.755
Occupations	1.66	-.070	1.69	-.100
Nativity	-.749	.063	-.634	-.052
Sum	.449	.551	.714	.287
Total		1		1
Panel C				
Differences in Decompositions	Black minus White Decomposition		Black minus White Decomposition	
Levels				
Sum	-.552	-.899	-.485	-.964
Total		-1.45		-1.45
Proportions				
Intercept	.988		.987	
Height	-1.90	.500	-1.90	.502
Ages	.255	-.497	.174	-.416
Occupations	-1.15	.112	-1.13	.089

Nativity	1.76	-.069	1.62	.074
Sum	-.045	.045	-.249	.249

Source: See Table 1.

Notes: Standard errors clustered on age.

5.4 Black Within-Group Decomposition

Table 4's Panel A is the black within-group decomposition, and African-American within-group net nutrition was greater under bound-labor. Independent of characteristics, black within-group net nutrition was higher under bound-labor, nonetheless, the source of within-group variation was important. Black weight returns to height and age were greater under bound-labor, yet was off-set, at least in part, by taller average black height and proportionally younger black workers under free-labor. Black weight-socioeconomic returns were greater under free-labor, indicating that black net nutrition returns were greater with the transition to free-labor. The black within-group weight decompositions were related to nativity, and nativity weight returns were greater under free-labor, after the institutionalized advantage to whites was eliminated. The black transition to free-labor for weights was nearly equally distributed to returns to characteristics and average characteristics.

5.5 White Within-Group Decomposition

Table 4's Panel B is the white weight within-group decomposition with the transition to free-labor. Like blacks, white weights were greater under bound-labor (Columns 2 and 4; Carson, 2018b); however, the white within-group decrease in net nutrition was smaller than blacks. The source of white weight returns varied with the transition to free-labor, and the white bound-labor autonomous source of differences was greater under bound-labor. Nevertheless, the

white, free-labor weight return associated with height was greater after the transition; conversely, average white statures were taller under bound-labor. The white weight-age return was greater under bound labor, however older whites were also incarcerated under free-labor. Socio-economic status was the largest source of the white free-labor weight advantage, and whites were in occupations with greater weight returns under free-labor. White within-group nativity returns were higher under bound-labor. Like blacks, white within-group weight differences between free and bound-labor were nearly equally distributed between returns to characteristics and average characteristics.

5.6 Within-Group Difference in Decompositions

Decomposing black and white weight within-group differences is insightful, and Table 4's Panel C shows the black within-group weight advantage decreased with the transition to free-labor. Like the across-group difference-in-decompositions, the source of the difference varied across characteristics. While overall white within-group net nutrition was higher with the transition to free-labor, the within-group autonomous intercept indicates that black unidentified within-group weight sources improved with the transition to free-labor. The white within-group weight-height advantage was greater under bound-labor, while the black within-group weight-height advantage was due to relatively taller blacks incarcerated under free-labor. The black within group weight returns advantage with ages and nativity increased more than whites with the transition, however composition results are mixed between bound and free-labor. During both periods, whites were comparatively older, yet the difference is small and varies across nativity. Black-white weight return differences by socioeconomic status favored whites with the transition to free-labor. In sum, white within-group weight variation was greater for stature and socioeconomic status, nonetheless black free-labor weight returns were greater for nativity.

6. Conclusion

The 19th century transition from bound to free labor exposed working class whites to competition from recently freed African-Americans. At the time, there was considerable concern what the labor market effect would be to low skilled whites. Away from the Civil War itself, the greatest race-related conflagration in US history was the 1863 summer race riot in lower Manhattan, where lower socioeconomic status whites—many of them recently arrived Irish immigrants—were unwilling to fight to free African-Americans, in part, because they believed free-blacks would increase competition with them for low skilled occupations. Nonetheless, this study shows that working class whites was better-off with the transition to free-labor, both across and within ethnic groups. Slave children's weight increased more than whites as they approached entry into the adult slave labor force, and older black weight gain under bound-labor was lower than under free-labor. At older ages, adult slave weight gain was lower than whites under bound-labor, extending a new pattern in black-white biological studies. Under discretion of slave masters, antebellum black weight gain under free-labor was less than whites. Agricultural worker's net nutrition were better than workers in other occupations but were worse-off under free-labor. Nativity had the greatest effect with weight changes and the transition to free-labor, and black weights after controlling for height and weights were greater under bound-labor. Across-group weight changes were greater than within-group weight changes. For both the across and within-group difference–in-decompositions, black weights decreased with the transition to free-labor. Therefore, rather than being worse off with the transition, free whites were made better off with the transition to free-labor.

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