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Assessing Cumulative Net Nutrition and the Transition from 19th Century Bound to Free-Labor by Ethnic Status

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Assessing Cumulative Net Nutrition and the Transition from 19th Century Bound to Free-labor by Ethnic Status

Abstract

Average stature reflects cumulative net nutrition and health during economic development. This study introduces a difference-in-decompositions approach to show that although 19th century African-American cumulative net nutrition was comparable to working class whites, it was made worse-off with the transition to free-labor. Average stature reflects net nutrition over the life-course, and slave children's BMIs increased more with age than whites as they approached entry into the adult slave labor force. Agricultural worker's net nutrition was better than workers in other occupations but was worse-off under free-labor and industrialization. Within-group stature variation was greater than across-group variation, and white within-group stature variation associated with socioeconomic status was greater than African-Americans.

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

Keywords: stature variation, cumulative net nutrition, Oaxaca decomposition.

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I. Introduction

The late 19th and early 20th century US political transition from bound to free-labor changed the economic, legal, and social institutions related to health and net nutrition for both African and European Americans. Arnold Plant (1947, pp. 3-16), C. Van Woodward (1951, p. 134), and Keith Tribe (2009, pp. 80 and 92) propose that lower socioeconomic status whites under free-labor were unable to compete with recently freed slaves and were made worse-off with the transition to free-labor (Donald, 1995, p. 24 and 417). On the other hand, if whites with the transition acquired a taste for discrimination, blacks would not have made as much economic, legal, and social progress because whites erected barriers to black material progress, which reduced black incentives to invest in net nutrition and health (Becker, 1957, pp. 75-80; Becker, 1966, pp. 188-190). Moreover, free-whites had an institutionalized advantage in their access to legal institutions, property rights, and human capital (Butler et al 1989). An extensive research shows how African-American statures compared to European-Americans who were allocated adequate nutrition under bound-labor, which provided them with sufficient nutrition to perform work (Fogel and Engerman, 1974, pp. 109-117; Fogel, 1989, pp. 132-142; David et al. 1976, pp. 178-184; Kahn, 1992, pp. 525-528; Margo and Steckel, 1992, pp. 517-519). Under free-labor, conditions were altered, changing the economic opportunities facing both blacks and whites, yet

it is unclear how white and black net nutrition varied with the transition to free-labor.[1] Subsequently, if white taste for discrimination against African-Americans increased with the transition to free-labor, lower socio-economic white statures would have increased relative to blacks, and black statures would have been worse-off with the transition to free-labor.

A population's average stature reflects the cumulative net difference between calories consumed and calories required for work and to withstand the physical environment, and the use of height data to measure net nutrition is now a well-accepted measure in economic development studies. Stature is related to health and labor market success, and taller individuals have greater access to opportunity and wages (Fogel, 1994, p. 375; Case and Paxon, 2008a; Case and Paxson, 2008b; Hammermesh and Biddle, 1994; Persico, Postlewaite, and Silverman, 2004; Gao and Smyth, 2010; Xiange and An, 2015). Throughout life, shorter individuals with low body mass have greater mortality risk, and shorter individuals are more likely to die from cardiovascular disease, various cancers, and stroke (Davie-Smith et al. 2000; Paajenen et al. 2010). On the other hand, taller stature is associated with aortic and pulmonary aneurisms (Brakken et al. 2010; Miedema et al. 2014; Emerging Risk Factors, 2012). Height is also related to cognition. With the transition to a free-labor force, black and white height differences varied and reflects how economic well-being changed by ethnic status, which reflects access to available resources, mortality risk, and labor market productivity (Persico et al. 2004; Perkins et al. 2016, pp. 152-157).

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[1] Individual statures vary due to complex interactions between genetics and the physical environment, and 60 percent of height in developing economies is determined by genetic factors, while nearly 80 percent of height is determined by genetic factors in developed economies (Cho et al., 2009; Lai, 2006; Luke et al. 2011).

It is against this backdrop that this study uses stature as a measure for cumulative net nutrition to assess how late 19th and early 20th century black and white statures varied with the transition to free-labor. Three questions are considered when evaluating the white and black stature transition to free-labor, and a difference-in-decompositions technique is introduced to isolate sources of stature variation between bound and free-labor. First, how did white and black statures vary with the transition to free-labor? White relative to black statures increased with the transition, and white within-group stature returns associated with socioeconomic status increased the most. Second, much has been written regarding black youth stature variation compared to whites under bound labor. How did white and black youth statures vary by age with the transition to free-labor? Adult age-related black stature loss was less than under bound-labor, indicating that although slaves were allocated sufficient calories to perform work under slavery, the transition to free-labor improved the age-related cumulative net nutrition for African-Americans. Third, what were the greatest sources of white and black stature variation with the transition to free-labor, and did white and black statures vary more across or within ethnic categories? On its surface, statures should have varied more across white and black statures; nonetheless, statures varied the most within ethnic categories, and socioeconomic status and nativity were the greatest source of the white within-group stature increase.

II. Data

Data for this project is the result of an extensive effort to collect and collate a broad set of physical characteristics from late 19th and early 20th century US prison records. 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. Reception dates began as early as 1803 and lasted through 1943. Birth dates begin in the 1730s and reach the 1920s. At the time of incarceration, enumerators recorded a broad set of characteristics, including age, occupations, ethnicity, birth period, nativity, and height.

Military and prison records are two sources used to evaluate late 19th and early 20th century stature variation. While plentiful, military statures represent conditions among higher socioeconomic groups and may suffer from an arbitrary truncation point imposed by minimum stature requirements for service (Fogel et al. 1978; Sokoloff and Vilaflor, 1982, pp. 456-458). Prison records are an alternative to military data and may have the advantage of being drawn from individuals with lower socioeconomic status, that segment of society most vulnerable to economic change. Prison records are, however, not above reproach. For example, inmates did not have sufficient income and wealth at the time of trial to afford legal counsel; therefore, poorer individuals may have been more likely to be incarcerated. On the other hand, prison officials may have judged that taller individuals were more likely to commit crimes because they were in better physical condition, which gave them an advantage in criminal interactions. Subsequently, law enforcement may have been more likely to incarcerate taller individuals.[2] The difference-in-decompositions presented here helps identify and control sample differences. In sum, it is not clear which segment of society prison records represent; however, it is generally accepted that prison records more likely represent conditions among lower socioeconomic groups.

[2] Floud et al. (2011, p. 331) present estimates for 19th century US stature variation, and their estimates are only .5 percent greater than average statures in the prison sample. In sum, there is little evidence that prisoners were targeted because of their height, and that prison records are more problematic than other samples.

Because ethnic classification was a primary means of identifying individuals within prisons, enumerators were thorough when recording inmate complexion. Complexion was also used to identify an inmate if they escaped and were recaptured. Individuals of African descent were classified as black, dark black, brown, chocolate, and various shades of 'mulatto.' Individuals of European descent were classified as white, fair, light, medium, and dark. The European complexion scheme is further supported because inmates claiming European ancestry were also recorded as white, light, fair, medium, and dark. Until the 1930s, in both US federal censuses and prisons, the term 'mulatto' was used to describe persons of mixed African and European ancestry. However, persons of mixed African and European ancestry are recorded as 'mixed-race' in the results that follow.[3] To isolate how economic and social processes were related before and after bound-labor, only black and white males are used in this study (Carson, 2009b; Carson, 2011a; Carson, 2013a).

Occupations are an important means of classifying socioeconomic status, and seven occupation categories are used here: white-collar, skilled, farmers, ranchers, farm laborers, unskilled, and workers with no recorded occupation. Bankers, merchants, and physicians are classified as white-collar workers. Blacksmiths, butchers, and tailors are classified as skilled workers. General farmers are classified as farmers, and ranchers and stockmen are classified as ranchers. There are farm and common laborers in the sample. Because farm laborers likely came to maturity under better biological conditions, including them in a single unskilled occupation category downwardly biases farm labor and upwardly biases common unskilled workers' cumulative net nutrition (Margo and Steckel, 1992, pp. 514-517; Carson, 2011b; Carson, 2013b).

[3] The Arizona and Montana prisons are the only prisons that, for at least a short period, included each individual's written descriptions and photograph.

Therefore, common and farm laborers are separated in the results that follow. A seventh category is included for workers with no listed occupations.

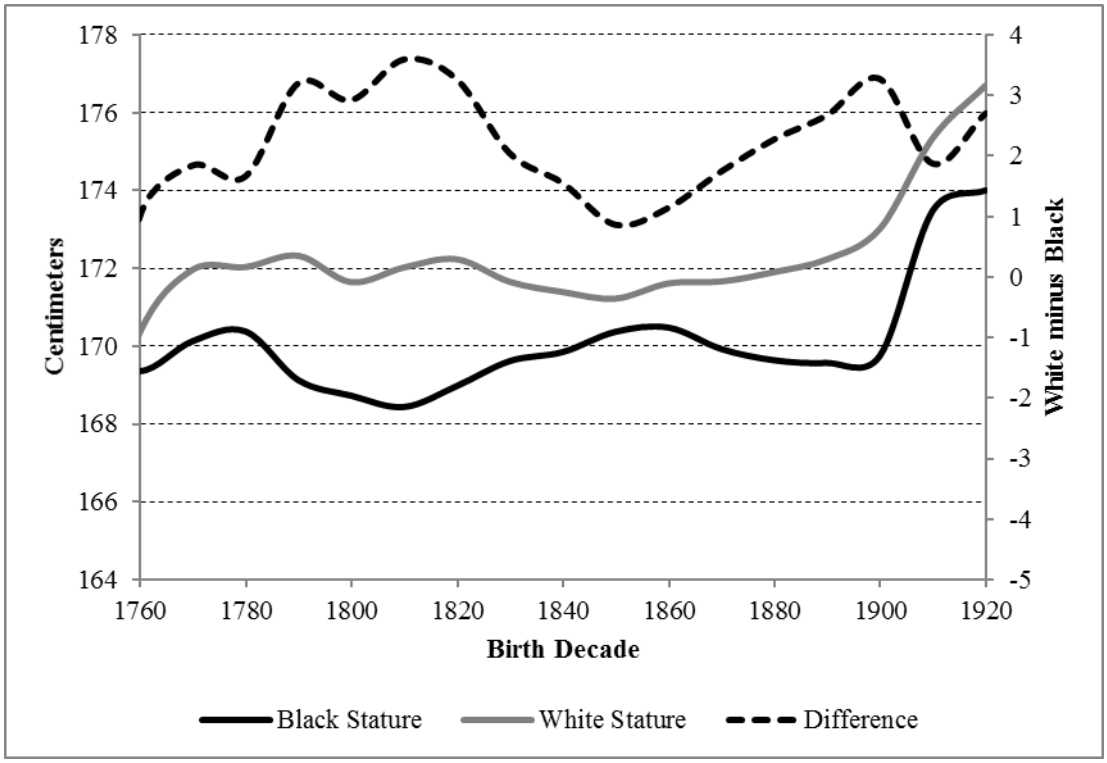

Figure 1, Late 19th and Early 20th Century Stature Variation by Birth over Time

Source: See Table 1.

Figure 1 plots average white and black statures for birth between 1760 and 1920. White statures were taller than black statures and follow the antebellum paradox (Komlos, 1987; Carson, 2009c). White's greatest cumulative net nutrition advantage was around 1810, when bound-labor was entrenched in US labor markets. On the other hand, average black stature increased relative to whites in the early 19th century and continued through the 1850s, which is consistent with the late antebellum cotton boom that favored black net nutrition (Wright, 1978; Rees et al., 2003; Carson, 2009b, p. 824). Before 1920, the smallest white-black stature gap was

in the 1850s and indicates that average statures were most similar just prior to the Civil War. Given the stature variation in Figure 1, the most reasonable period to specify a change in white and black cumulative US net nutrition is, therefore, the 1865 transition from bound to free-labor.

Table 1, Average Characteristics for Blacks and Whites Bound and Free Labor

	White, Bound Labor		*Black, Bound Labor*		*White, Free Labor*		*Black, Free Labor*	
	Average	S.D.	Average	S.D.	Average	S.D.	Average	S.D.
Average Age	31.92	11.75	30.50	11.73	26.34	7.30	24.23	6.64
Ages	N	Percent	N	Percent	N	Percent	N	Percent
Teens	8,197	9.64	4,475	12.60	13,320	15.11	14,282	25.12
20s	36,047	42.44	16,460	46.36	51,110	57.98	32,444	57.07
30s	20,610	24.27	7,367	20.75	18,278	20.74	8,147	14.33
40s	11,669	13.74	4,074	11.47	4,649	5.27	1,801	3.17
50s	5,985	7.05	2,160	6.08	690	.78	161	.28
60s	2,423	2.85	969	2.73	101	.12	12	.02
Occupations								
White-Collar	9,305	10.96	1,483	4.18	11,286	12.80	1,910	3.36
Skilled	22,874	26.93	4,100	11.55	21,190	24.04	5,749	10.11
Farmer	10,539	12.41	2,879	8.11	11,089	12.58	5,963	10.49
Rancher	230	.27	10	.03	983	1.12	29	.05
Farm Laborer	394	.46	550	1.55	543	.62	92	.16
Unskilled	31,799	37.44	18,973	53.44	38,497	43.67	33,570	59.05
No Occupation	9,790	11.53	7,510	21.15	4,560	5.17	9,534	16.77
Nativity								
Northeast	3,650	4.30	213	.60	1,657	1.88	170	.30
Middle Atlantic	30,893	36.37	6,950	19.57	13,263	15.05	2,359	4.15
Great Lakes	20,896	24.60	1,611	4.54	20,927	23.74	2,836	4.99
Plains	6,504	7.66	2,260	6.37	20,667	23.45	6,680	11.75
Southeast	17,836	21.00	19,455	54.80	16,640	18.88	28,139	49.50
Southwest	2,618	3.08	4,858	13.68	8,697	9.87	16,219	28.53
Far West	2,534	2.98	158	.45	6,297	7.14	444	.78

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; California State Archives, 1020 O Street, Sacramento, CA 954814; 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; Maryland State Archives, 350 Rowe Building, Annapolis, MD 21401; 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; Ohio Archives Library, 800 E. 17th Avenue, Columbus, OH43211; 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 and 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.

White and black statures are partitioned into four groups: whites and blacks born before 1866 and whites and blacks born after 1865. Table 1 illustrates that throughout the late 19th and early 20th centuries that whites were a larger portion of the prison population and more likely to be in white-collar, skilled workers, and agricultural occupations. Blacks were always less likely than whites to be skilled, and the proportion of blacks in skilled occupations was comparable before and after the transition to free-labor. However, with the end of slavery, blacks were more likely to own or tenant land and took up a larger proportion in agricultural occupations for birth after 1865 (Maloney, 2002). Blacks were more likely to be unskilled and workers without occupations, and the proportion of unskilled whites increased under free-labor, which is likely related to immigration (Cohn, 2009). Nativity from the Northeast, Middle Atlantic, and Southeast decreased over time, while nativity from the Plains, Southwest, and Far West

increased. The proportion from the Great Lakes remained about the same throughout the period. While there was a considerable share of immigrants in prison records, to isolate the US labor market transition from bound to free-labor, only US born individuals are considered here. In sum, the prison composition for individuals born under both bound and free-labor was more likely young, unskilled black workers; however, black farmers became more prominent over time.

III. Econometric Model

Separating results into treatment and control groups before and after an event is a practical means to isolate variation due to changes in returns to characteristics and changes due to average characteristics (Oaxaca, 1973; Lee, 2005). If there is a measureable difference between returns to characteristics before and after bound-labor with similar average characteristics, the effects of the transition to free-labor is more likely due to the transition. If, however, there is little difference between returns to characteristics before and after bound-labor and a large difference between average characteristics, the effects of the transition are associated with differences in sample compositions.

A popular method to establish causal inference in the quasi-experiment literature is a difference-in-difference estimator, which mimics an experimental research design using observational data. When treatment is randomly assigned, the difference-in-difference estimator also isolates the treatment effect on the response variable by comparing average changes between treatment and control groups.[4] A Blinder-Oaxaca decomposition is a statistical

[4] β_{Δ} is a consistent and unbiased estimate of the causal effect:

procedure used to partition the difference between response variables into differences due to characteristic returns and average characteristics (Oaxaca, 1973).

Let Y_c and Y_t be control and treatment response models.

$$Y_c = \alpha_c + \beta_c \overline{X}_c \qquad (1)$$

and

$$Y_t = \alpha_t + \beta_t \overline{X}_t \qquad (2)$$

where α_c and α_t are the control and treatment group autonomous components. β_c and β_t are control and treatment stature partial derivatives with respect to characteristics. X_c and X_t are control and treatment average characteristic matrices. A decomposition separates the difference between response variables.

$$\Delta Y = Y_t - Y_c = \alpha_t + \beta_t \overline{X}_t - \alpha_c - \beta_c \overline{X}_c \qquad (3)$$

Adding and subtracting $\beta_t X_c$ to the right hand-side, and collecting like terms is the decomposition

$$\Delta Y = Y_t - Y_c = (\alpha_t - \alpha_c) + (\beta_t - \beta_c)\overline{X}_c + (\overline{X}_t - \overline{X}_c)\beta_t \qquad (4)$$

$\beta_\Delta = (\overline{Y}_{t,t+1} - \overline{Y}_{t,t}) - (\overline{Y}_{c,t+1} - \overline{Y}_{c,t}) = \Delta\overline{Y}_t - \Delta\overline{Y}_c$ where $\overline{Y}_{t,t+1}$ and $\overline{Y}_{t,t}$ are conditional response variables on the treatment group before and after an event. $\overline{Y}_{c,t+1}$ and $\overline{Y}_{c,t}$ are the conditional response variable on the control group before and after the event.

The objective of a difference-in-decompositions is to partition the difference in response variables into percent differences due to returns to characteristics and average characteristics between bound and free-labor. These percent differences-in-decompositions are the differences between how the response variable changes with the transformation to free-labor.[5]

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

$$S_w^{bound} = \alpha_w^{bound} + \beta_w^{bound} \overline{X}_w^{bound} \quad (5)$$

$$S_b^{bound} = \alpha_b^{bound} + \beta_b^{bound} \overline{X}_b^{bound} \quad (6)$$

$$S_w^{free} = \alpha_w^{free} + \beta_w^{free} \overline{X}_w^{free} \quad (7)$$

$$S_b^{free} = \alpha_b^{free} + \beta_b^{free} \overline{X}_b^{free} \quad (8)$$

where S_w^{bound} are white statures born before 1866, and S_w^{free} are whites born after 1865. S_b^{bound} and S_b^{free} are defined similarly for African-Americans.[6]

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[5] There is concern regarding the value of decomposing dependent variable differences into returns to characteristics and average characteristics because estimated coefficients vary with respect to the choice of the omitted category (Oaxaca and Ranson, 1999). There is little concern about explaining the difference in dependent variable gap due to average characteristics, $\left(\overline{X}_t - \overline{X}_c\right)\beta_t$. However, because the intercept is sensitive to the omitted category, identification of $\left(\alpha_t - \alpha_c\right) + \left(\beta_t - \beta_c\right)\overline{X}_c$ is less clear. Some degree of arbitrariness is unavoidable (Yun, 2008; Fortin, Lemieux, and Firpo, 2001, pp. 40 and 45. Although there are other interpretations, this "unexplained gap" is often interpreted as the difference attributed to structure.

[6] a_w^{bound} and a_w^{free} are the intercepts for white males born before and after 1865; a_b^{bound} and a_b^{free} are defined in like fashion for blacks. β_w^{bound} and β_b^{bound} are the white and black stature characteristics for the bound-labor control

There are two ways to compare the effects of an event between groups: across and within-groups. The across-group decomposition isolates the white-black stature difference between bound and free-labor. The within-group decomposition isolates the difference in response variables within groups between bound and free-labor. The white and black across-group difference-in-decompositions is considered first, followed by a within-group decomposition.

Across-groups Decomposition

The across-group decomposition identifies white and black stature differences with the transition to free-labor attributable to returns to characteristics versus average characteristics. To start, the across-group difference-in-decompositions is calculated by taking the white and black stature decompositions under free and bound -labor. For both the free and bound-labor decompositions, white stature is the base stature because whites were, on average, taller than blacks (Carson, 2009c).

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

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

The difference-in-decompositions is the difference in the free and bound labor across group decompositions.

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group. β_w^{free} and β_b^{free} are defined similarly for the post transition white and black stature returns. $\overline{X}_w^{bound}$ and $\overline{X}_w^{free}$ the matrix of white male characteristics before and after 1865. $\overline{X}_b^{bound}$ and $\overline{X}_b^{free}$ are the black average characteristics defined in the same way.

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

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

which is re-written as

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

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

Equation 12 is the white-black across-group stature decomposition.

Within Group Decomposition

There was also a stature difference within white and black groups with the transition to free-labor, which illustrates how stature returns within ethnic groups varied with the transition to free-labor. The within-group decomposition is calculated by taking the stature difference within groups before and after bound-labor and illustrates the sources of the within-group changes associated with the transition to free-labor. Free-labor statures are the base structure.

$$\Delta S_{White} = \left(\alpha_w^{free} - \alpha_w^{bound}\right) + (\left(\beta_w^{free} - \beta_w^{bound}\right)\overline{X}_w^{bound}) + (\left(\overline{X}_w^{free} - \overline{X}_w^{bound}\right)\beta_w^{post}) \quad (13)$$

$$\Delta S_{Black} = \left(\alpha_b^{free} - \alpha_b^{bound}\right) + (\left(\beta_b^{free} - \beta_b^{bound}\right)\overline{X}_b^{bound}) + (\left(\overline{X}_b^{free} - \overline{X}_b^{bound}\right)\beta_b^{free}) \quad (14)$$

The within group difference-in-decompositions is then derived by taking the difference after and bound-labor.

$$\Delta S_{\Delta} = \Delta S_{white} - \Delta S_{black} = \left(\alpha_w^{free} - \alpha_w^{bound}\right) + (\left(\beta_w^{free} - \beta_w^{bound}\right)\overline{X}_w^{bound}) + (\left(\overline{X}_w^{free} - \overline{X}_w^{bound}\right)\beta_w^{free})$$

$$-\left(\alpha_b^{free}-\alpha_b^{bound}\right)-(\left(\beta_b^{free}-\beta_b^{bound}\right)\overline{X}_b^{bound})-(\left(\overline{X}_b^{free}-\overline{X}_b^{bound}\right)\beta_b^{free}) \quad (15)$$

which is written as

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

$$+\left(\overline{X}_w^{free}-\overline{X}_w^{bound}\right)\beta_w^{free}-\left(\overline{X}_b^{free}-\overline{X}_b^{bound}\right)\beta_b^{free} \quad (16)$$

Equation 16 is the white-black within-group stature decomposition.

IV. Black and White Statures during Bound and Free-Labor

Nineteenth century black and white statures were related to age, occupations, and nativity. To determine how statures and net nutrition were related by ethnic status with the transition to free labor, statures are regressed on demographics, socioeconomic status, and nativity by birth period. Four models are presented: whites and blacks born before 1866, and whites and blacks born after 1865.

$$Cent_i^j=\theta_0+\sum_{a=1}^{15}\theta_a Age_i^j+\sum_{l=1}^{6}\theta_l Occupation_i^j+\sum_{n=1}^{6}\theta_n Nativity_i^j+\varepsilon_i^j \quad (17)$$

where *i* is ethnicity and *j* is pre and post 1865 birth. Youth annual age dummy variables are included to account for how statures varied between 12 and 22. Adult age decade dummy variables are included for ages 30 through 60. Occupation dummy variables are included for white-collar, skilled, farmers, ranchers, farm-laborers, and unskilled occupations. To account for net nutrition by nativity, dummy variables are included for birth in Middle Atlantic, Great Lakes, Plains, Southeast, Southwest, and Far West regions.

Table 2's Model 1 is white statures in centimeters as a function of age, occupations, and nativity for birth before 1865. Model 2 does the same for blacks. Model 3 is the white stature model for birth after 1865, and Model 4 does the same for blacks.

Table 2. Black and White, Before and After Regression Models by Demographics and Socioeconomic Status

	Model 1	*Model 2*	*Model 3*	*Model 4*
	White, Bound Labor	Black, Bound Labor	White, Free Labor	Black, Free Labor
Intercept	171.18***	169.97***	169.77***	167.70***
	(.118)	(.239)	(.156)	(.312)
Ages				
12	-22.13***	-20.00***	-16.93***	-21.87***
	(.027)	(.021)	(.048)	(.029)
13	-16.01***	-16.04***	-13.69***	-15.37***
	(.027)	(.030)	(.037)	(.028)
14	-15.70***	-13.47***	-12.76***	-11.37***
	(.029)	(.014)	(.036)	(.031)
15	-9.63***	-9.79***	-8.04***	-7.93***
	(.020)	(.025)	(.022)	(.024)
16	-6.14***	-6.32***	-4.93***	-4.94***
	(.016)	(.032)	(.026)	(.025)
17	-3.99***	-4.47***	-2.79***	-3.15***
	(.017)	(.017)	(.016)	(.020)
18	-2.76***	-3.09***	-1.52***	-2.14***
	(.012)	(.015)	(.017)	(.018)
19	-1.29***	-1.58***	-1.02***	-1.31***
	(.010)	(.016)	(.013)	(.012)
20	-.969***	-1.08***	-.410***	-.402***
	(.007)	(.006)	(.013)	(.014)
21	-.312***	-.344***	-.180***	-.368***
	(.006)	(.005)	(.008)	(.009)
22	.056***	.023***	-.204***	-.375***
	(.005)	(.006)	(.005)	(.006)
23-29	Reference	Reference	Reference	Reference
30s	.076***	.061***	.100***	.233***
	(.007)	(.009)	(.005)	(.006)
40s	-.041***	-.530***	-.097***	-.324***
	(.010)	(.012)	(.010)	(.012)
50s	-.523***	-1.23***	-.481***	-.668***

	(.011)	(.016)	(.018)	(.022)
60s	-1.12***	-1.87***	-.540**	-.112**
	(.070)	(.097)	(.227)	(.044)
Occupations				
White-Collar	-.376***	-.828***	1.21***	1.02***
	(.142)	(.159)	(.061)	(.108)
Skilled	-.234**	.079	1.09***	.865***
	(.097)	(.196)	(.062)	(.143)
Farmer	1.27***	1.05***	2.37***	2.17***
	(.104)	(.153)	(.083)	(.517)
Rancher	.886**	1.59*	3.08***	2.68***
	(.334)	(.878)	(.136)	(.517)
Farm Laborer	.301	-.324	3.26***	3.30
	(.388)	(.274)	(.458)	(2.35)
Unskilled	-.086	-.121	1.39***	1.45***
	(.117)	(.147)	(.047)	(.085)
No Occupation	Reference	Reference	Reference	Reference
Nativity				
Northeast	Reference	Reference	Reference	Reference
Middle Atlantic	-.600***	-.849***	-.708**	-.472**
	(.070)	(.258)	(.247)	(.220)
Great Lakes	1.20***	1.51***	.793***	1.05**
	(.100)	(.194)	(.184)	(.396)
Plains	1.17***	.433	1.62***	.752**
	(.135)	(.338)	(.171)	(.324)
Southeast	2.05***	.958***	1.82***	1.76***
	(.096)	(.250)	(.165)	(.292)
Southwest	3.28***	3.03***	2.41***	3.23***
	(.397)	(.311)	(.108)	(.359)
Far West	-.330***	.101	1.30***	1.43**
	(.058)	(.499)	(.097)	(.540)
N	84,931	35,505	88,148	56,847
R^2	.0718	.1024	.0535	.1190

Source: See Table 1.

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

Antebellum Period and Bound-labor

Among the most telling biological relationships that illustrate the effects of the transition from bound to free-labor is the association between stature and age. Catch-up growth is the biological phenomenon where an individual who is deprived of net nutrition during early growth years experiences accelerated stature growth if sufficient net nutrition is restored before stature growth ceases, which allows them to return to their genetically predetermined growth profile (Bereman, 2016).[7] An established pattern in ante-bellum stature studies is that for each age group, young slaves were shorter than whites but experienced greater catch-up growth as they approached adult ages and entered the adult labor force (Steckel, 1986a, p. 724; Steckel, 1986b; Schneider, 2017).[8] For the most part, antebellum black youth statures increased as they approached entry into the adult labor force (Table 2; Margo and Steckel, 1992, pp. 517-518; Steckel, 1986a; Steckel, 1986b; Steckel and Ziebarth, 2016). On the other hand, older black stature loss under bound-labor was greater than whites due to years of arduous physical labor associated with age-related degenerative joint disease (Kelly and Angel, 1987; Rathbun, 1987, p. 244; Haboubi et al. 1990; Huang et al. 2013). From skeletal remains, blacks under bound-labor exhibited stature loss consistent with high workloads and physical accidents that may not have occurred had older African-Americans been free to choose their occupations and work effort devoted to physical activity throughout life (Davidson et al. 2002, pp. 267-268, Rathbun 1987,

[7] In modern populations, over 86 percent of small-for-gestational-age children experience catch-up growth during the first six to 12 months of life (Albersson-Wikland and Karlberg, 1995; Behrman, 2016).

[8] John Komlos (1992, p. 300) questions whether the results are from the peculiarity of the manifest samples or from children's labor force participation rates. While the Maryland sample supports the position that slave children were under nourished, they were less malnourished than suggested by the manifest sample (Schneider, 2017, pp. 9-12).

pp. 248 and 251; and Rathbun and Steckel, 2002, pp. 215-221). Moreover, the early onset of degenerative diseases at older ages may be linked to inadequate cellular development in early life (Fogel, 1994, p. 381). Subsequently, while black youth stature growth prior to their entry into the adult labor force has been postulated for some time, black adult age-related stature loss was greater than whites but decreased with the transition to free-labor.

Under bound-labor, stature variations by occupation results are mixed. White-collar and skilled workers likely received poor net nutrition because of separation of food production from food consumption (Komlos, 1987; Carson, 2008a, pp. 366-368; Dirks, 2016, pp. 39-40 and 60-62). Alternatively, white and black general farmers were taller than workers in other occupations, and the occupation-stature relationship for unskilled workers under bound-labor was comparable to workers with no recorded occupation (Carson, 2009c, p. 155). Under bound-labor, individuals from urbanizing Northeast and Middle Atlantic states were shorter than individuals from elsewhere within the US, while workers from the Great Lakes and South were taller (Zehetmeyer, 2011). Moreover, under bound-labor, the regional advantage that accrued to whites did not extend to blacks native to the Plains, and US born whites in the Far West had lower net nutrition compared to other areas within the US (Carson, 2015; Carson, 2013b).

Post Bellum Period and Free-labor

Black and white stature variation after emancipation is noteworthy and illustrates the cumulative net nutrition changes associated with the transition to free-labor. Under free-labor, young blacks were less likely to experience catch-up growth, in part, because they were no longer under the paternalistic slave system. Under free-labor, black household heads had greater direction over household resources and had the ability to care for their off-spring by providing

them nutrition throughout their growing years (Higgs, 1977; Steckel, 1992, p. 504; Margo and Steckel, 1992, pp. 517-518; Rathbun and Steckel, 2002). Under free-labor, adult black age-related stature loss was also lower relative to bound-labor (Table 2, Models 1 and 2). When African-Americans were no longer subject to bound-labor, their cumulative net nutrition improved, especially for black men older than 50 (Higgs, 1977, pp. 62-64).

Under free-labor, the white-black occupational stature relationship converged with patterns in a developed labor market (Ransom and Sutch, 1977, pp. 31-39). Under bound, occupations were not clearly defined, and the majority of workers—whether or not they listed agriculture as their primary occupation—were, in some way, associated with agriculture, if only for transportation and household production (Dimitri et al. 2005). Under free-labor and early industrialization, labor markets became more specialized, and workers were separated from more nutritious diets associated with agricultural occupations (Rosenbloom, 2002, p. 88). The cumulative difference in net nutrition increased for white-collar and skilled workers relative to workers under bound-labor, indicating that skilled worker cumulative net nutrition improved with the transition to free-labor (Margo and Steckel, 1992, p. 518).

Across the US, white regional stature returns mostly decreased with the transition to free-labor. After slavery, individuals from the Northeast and Middle Atlantic continued to be shorter than individuals from elsewhere within the US; Plains workers continued to be taller. However, under free-labor, black and white net nutrition in the Far West experienced a marked improvement, and cumulative net nutrition improved with immigration and the opening of the West (Turner, 1893; Carson, 2010; Komlos and Carson, 2017; Carson, 2017). After 1865, immigration increased and new arrivals moved west to take advantage of abundant farm lands in recently settled Plains and Western states (Galloway and Vedder, 1971; Galloway and Vedder,

1980; Cohn, 2009, pp. 173-186; Ferrie, 1999, pp. 64-70). In sum, under free-labor, the cumulative net nutrition of younger blacks was no longer under slave masters' control, and their cumulative net nutrition decreased; older black age-related stature loss was greater under bound-labor, and cumulative net nutrition converged to occupations in a developed labor market.

V. Black and White Stature Returns: A Difference in Decompositions Approach

Isolating stature changes across and within ethnic groups illustrates how comparative net nutrition was related to the transition to free-labor. Table 3's Panel A is the white-black stature decomposition for individuals born under free-labor (Equation 9). Panel B is the white-black stature decomposition for individuals born under bound-labor (Equation 10). Panel C is the across-group difference-in-decompositions, and elements are the stature percent changes across-groups associated with the transition to free-labor (Equation 12). For example, the intercept difference between free and bound-labor demonstrates how white and black autonomous stature's non-identifiable characteristics varied with the transition to free-labor. If the difference is positive, the white autonomous stature difference increased relative to blacks under free-labor and negative if the white-black difference was greater under bound-labor (Oaxaca and Ransom, 1999). From raw means, white statures under bound-labor were 1.43 centimeters taller than blacks. Under free-labor, this advantage increased, and average white statures were 2.01 centimeters taller than blacks (Table 3). The difference-in-decompositions illustrates the source of white and black stature differences associated with the transition to free-labor.

Table 3, Across-Group Difference in Decompositions

Panel A	*Column 1*	*Column 2*	*Column 3*	*Column 4*
Free-Labor Decomposition	$\left(\beta_w^{free} - \beta_b^{free}\right)X_b^{fr}$	$\left(X_w^{free} - X_b^{free}\right)\beta_w^{free}$	$\left(\beta_w^{free} - \beta_b^{free}\right)X_w^{free}$	$\left(X_w^{free} - X_b^{free}\right)\beta_b^{free}$
	Column 1 **Structure**	*Column 2* **Composition**	*Column 3* **Structure**	*Column 4* **Composition**
Levels				
Sum	2.22	-.056	2.38	-.214
Total		2.17		2.17
Proportions				
Intercept	1.02		1.02	
Ages	.048	.212	.030	.230
Occupations	-.008	.068	.026	.034
Nativity	-.033	-.306	.024	-.363
Sum	1.03	-.026	1.10	-.099
Total		1		1
Panel B				
Bound-Labor Decomposition	$\left(\beta_w^{bound} - \beta_b^{bound}\right)2$	$\left(X_w^{bound} - X_b^{bound}\right)\beta_w^{b}$	$\left(\beta_w^{bound} - \beta_b^{bound}\right)X_w^{b}$	$\left(X_w^{bound} - X_b^{bound}\right)\beta_b^{b}$
	Structure	**Composition**	**Structure**	**Composition**
Levels				
Sum	2.45	-.669	2.01	.228
Total		1.78		1.78
Proportions				
Intercept	.973		.973	
Ages	.077	.123	.087	.113
Occupations	-.116	.003	-.127	.014
Nativity	.442	-.503	.195	-.255
Sum	1.38	-.376	1.13	-.129
Total		1		1
Panel C				
Difference-in-Decompositions	After minus before		After minus before	
Levels	-.222	.613	.377	.014
Sum		.391		.391
Total				
Proportions				
Intercept	.046		.046	
Ages	-.029	.089	-.057	.117
Occupations	.108	.064	.152	.020
Nativity	-.475	.197	-.171	-.108
Sum	-.351	.351	-.030	.030

Source: See Tables 1 and 2.

Across-Group Free-Labor Decomposition

The free-labor across-group decomposition (Table 3, Panel A) demonstrates that white stature returns were positive for unidentified sources in the intercept and age; however, under free-labor, white average ages were older than blacks and were a greater source of the age-related stature difference (Table 1). There was, however, a small share of the free-labor across-group stature difference due to returns to occupations and residence, such as farmers and ranchers, but the differences are small and switches between reference points. Most of the free-labor white-black stature difference associated with socio-economic status and residence were due to composition differences rather than returns to characteristics. There were also more blacks in the South who had taller average statures because the South was agriculturally more productive than other regions within the US (Ransom and Sutch, 1977, pp. 150-155; Carson, 2008b; Carson, 2009c). Most of the free-labor white-black stature differential was due to differences in stature returns and not average characteristics.

Across-Group Bound-Labor Decomposition

The across-group bound-labor decomposition demonstrates that white stature returns were greater than blacks for the intercept, age, and residence (Table 3, Panel B, columns 1 and 3). Under bound-labor, whites had greater stature returns associated with ages, and white average ages were older than blacks (Table 1). Most of the white-black bound-labor age-related stature difference was due to older average white ages under bound labor. However, blacks had large stature returns by socioeconomic status, and little of the difference was associated with

differences in sample compositions, indicating there were large cumulative net nutrition differences by socioeconomic status under bound-labor. The greatest share of the bound-labor stature advantage was returns to residence. For example, whites in the Southeast stature returns were over 100 percent greater than Southeastern black stature returns (Table 2, Models 1 and 2). Nevertheless, under bound-labor, blacks remained in the South, where net nutrition was high (Table 3, Panel B, Columns 1 and 3; Hilliard, 1972; Carson, 2008b; Carson, 2009a). Most of the white-black bound-labor stature differential was due to returns to characteristics rather than average characteristics.

Across-Group Difference-in-Decompositions

Table 3, Panel C, illustrates that free and bound-labor percent differences were due to both changes in returns and average characteristics. Three hypotheses are now tested with a difference-in-decompositions. First, Arnold Plant (1947, pp. 3-16) and Woodward (1951, p. 134) propose that after slavery, lower socioeconomic status whites were unable to compete with recently freed slaves and created political barriers to black upward economic mobility through Jim Crow laws and disparate access to human capital (Tribe, 2009, pp. 80 and 92; Collins and Margo, 2006, Tables 1, 2, and 6). By 1896, these white economic and legal advantages were codified throughout the US under *Plessy v. Ferguson* when the Supreme Court upheld disparate white and black access to public resources. However, if whites displayed greater discrimination with the transition, blacks would not have made as much net nutritional progress. The .391 centimeters increase in white statures with the transition to free-labor demonstrates there was an increase in white relative to black average statures with the transition to free-labor (Table 3, Panel C), and the size of the increase indicates that the white autonomous stature advantage increased relative to blacks under free-labor after controlling for stature returns and average

characteristics.[9] Subsequently, rather than being worse-off with the transition to free-labor, white net nutrition was better off relative to blacks with the transition to free-labor.

Second, the difference-in-decompositions isolates other sources of the free and bound-labor differences due to characteristics and returns to average characteristics. There was an increase in black stature returns to age with the transition to free-labor. However, the decrease in the white stature advantage associated with age was off-set by relatively older whites incarcerated under free-labor (Table 1). While black youth catch-up growth under slavery has long been recognized as a source of white and black statures, adult black stature loss under slavery at older ages introduces an important dimension of the US labor market transition to free-labor.[10] Whites were taller than blacks under free-labor due to greater stature returns to occupations, and the increase in the white free-labor stature advantage was due more to differences in returns to occupations than whites in occupations with taller average stature. For the most part, cumulative net nutrition by residence in the South before and after slavery was favorable toward blacks, and with emancipation, the white residence net nutritional advantage decreased relative to blacks. Consequently, the across-group difference-in-decompositions

[9] Biases may exist because prison selection processes changed between bound and free labor; however, the difference-in-decompositions accounts for sample differences between the two periods, and white statures increased relative to blacks associated with socioeconomic status but were worse off under free-labor once Southern whites no longer had an institionalized advantage to bound blacks.

[10] John Komlos (1992, p. 300) questions whether the results presented by Steckel (1986a) are genuine or the result of the manifest sample's childhood participation rates. While the Maryland sample supports the position that slave children were not well nourished, using percentiles to describe catch up growth only describes relative catch-up growth, which may lead Steckel to understate catch-up growth (Schnieder 2017, pp. 9-12).

illustrates that white cumulative net nutrition improved relative to blacks with free-labor, and regional stature effects favored whites in the antebellum South.

Within Group Free and Bound Stature Decompositions

Table 4's Panel A is the white free and bound-labor within-group stature decomposition (Equation 13). Panel B is the black free and bound-labor within-group stature decomposition (Equation 14). Panel C is the within-groups difference-in-decompositions between free and bound-labor, which isolates the difference between how white and black statures varied within ethnic groups with the transition to free-labor (Equation 16). Panel C elements are the within-group stature percent changes associated with the transition to free-labor. For example, if within-group element differences are positive, white within-group stature differences were greater with the transition to free-labor and negative if the black within-group stature differences were greater with the transition to free-labor.

Table 4, Within-Group Difference in Decompositions

Panel A				
White Decomposition	$\left(\beta_w^{free} - \beta_w^{bound}\right)X_w^{free}$	$\left(X_w^{free} - X_w^{bound}\right)\beta_w^{bound}$	$\left(\beta_w^{free} - \beta_w^{bound}\right)X_w^{bound}$	$\left(X_w^{free} - X_x^{bound}\right)\beta_w^{free}$
	Column 1	*Column 2*	*Column 3*	*Column 4*
	Structure	**Composition**	**Structure**	**Composition**
Levels				
Sum	.070	.370	-.185	.625
Total		.440		.440
Proportions				
Intercept	-3.21		-3.21	
Ages	.356	-.232	.272	-.147
Occupations	3.05	.010	2.81	.251
Nativity	-.046	1.06	-.299	1.32
Sum	.159	.841	-.420	1.42
Total		1		1
Panel B				
Black Decomposition	$\left(\beta_b^{free} - \beta_b^{bound}\right)X_b^{free}$	$\left(X_b^{free} - X_b^{bound}\right)\beta_b^{bound}$	$\left(\beta_b^{free} - \beta_b^{bound}\right)X_b^{bound}$	$\left(X_b^{free} - X_b^{bound}\right)\beta_b^{free}$
	Structure	**Composition**	**Structure**	**Composition**
Levels				
Sum	-.301	.182	-3.45	.227
Total		-.118		-.118
Proportions				
Intercept	19.18		19.18	
Ages	-2.41	3.44	-1.93	2.96
Occupations	-10.05	-.240	-9.18	-.568
Nativity	.418	-4.74	-4.61	-4.30
Sum	2.54	-1.54	2.92	-1.92
Total		1		1
Panel C				
Difference- in-Decompositions	White Difference minus Black Difference			
Levels				
Sum	.370	.188	.160	.398
Total		.558		.558
Proportions				
Intercept	-22.39		-22.39	
Ages	2.76	-3.67	2.20	-3.10
Occupations	13.11	.250	12.54	.819
Nativity	4.13	5.80	4.31	5.62
Sum	-2.38	2.38	-3.34	3.34

Source: See Tables 1 and 2.

White Within-Group Decomposition

Table 4's Panel A shows that white cumulative net nutrition within ethnic status increased with free-labor. From the intercept, the autonomous white cumulative net-nutrition was greater under bound-labor. Under bound-labor, whites had an institutionalized advantage to blacks, and the removal of that advantage meant that whites were worse-off within-group under free labor. However, there were differences in returns to characteristics with the transition to free-labor. For example, white within-group age returns were greater under free-labor, yet white average age was older under bound-labor. Socioeconomic status was the primary characteristic associated with improvements in white statures and the transition to free-labor and was due to characteristic returns; there were only minor white average occupation differences. Labor market development more clearly defined occupational categories and increased white relative net nutrition with labor market development. White stature returns associated with nativity were greater under bound-labor. During the antebellum period, white social standing was greater than blacks (Table 3, Panel B) but also greater than whites under free-labor (Table 4, Panel A); however, there were more whites in the South under free-labor, and the South was agriculturally more productive than elsewhere within the US. Most of the white within-group stature difference between free and bound-labor was due to higher average characteristics during free-labor and not returns to characteristics.

Black Within-Group Decomposition

Stature returns within the African-American cohort were even more pronounced than whites—because there was a small difference between if free and bound black net nutrition—and blacks received greater cumulative net nutrition under bound-labor (Table 4, Panel B). The difference in black autonomous stature components indicates the autonomous black stature difference was large, but the source of the black stature difference was important in the transition to free-labor. Black within-group age-related stature returns were greater under bound-labor, which includes both greater stature growth for young blacks and adult stature loss under bound-labor. However, black average age was older under free-labor. The greatest source of the black within-group stature variation was occupations, and black net nutrition returns by socioeconomic status were considerably higher under bound-labor. The average stature difference associated with socioeconomic status was large under bound labor, indicating the greatest share of the black stature difference between bound and free-labor was associated with poor cumulative net nutrition by socioeconomic status with the transition to free-labor. Stature returns by nativity are mixed, but there were more blacks in the South under bound-labor, and the South was more agriculturally productive than elsewhere within the US (Sunstrom, 2013, p. 324; Farley and Allen, 1987, pp. 113 and 118; Gregory, 2005). Most of the black within-group stature difference between free and bound-labor was due to greater black free-labor returns to characteristics.

Within-Group Difference-in-Decompositions

Decomposing white and black stature differences within groups is insightful. Table 4's Panel C shows that the white within-group free-labor transition was associated with a .558 centimeters net increase in white statures relative to blacks with the transition to free-labor; however, the negative within-group stature intercept difference indicates white autonomous stature differences relative to blacks were greater under bound-labor. By ages, white stature

returns were greater with the transition to free-labor; however, blacks were older under free-labor. By occupations, the white relative to black stature gap increased considerably with the transition to free-labor, and there was little difference in occupation compositions, indicating that much of the improvement in white net nutrition was associated with structural returns to socioeconomic characteristics. Throughout the late 19th and early 20th centuries, white and black agricultural workers' cumulative net nutrition was better than workers in other occupations, and agriculture advantage increased with the transition to free-labor (Table 2). There were large net nutrition returns by nativity that favored whites with the transition to free-labor; however, more of the within-group white stature advantage was due to Southern whites incarcerated under free-labor. In sum, the white within-group stature return variation associated with occupations and socioeconomic status were the primary source of the white within-group stature advantage, followed by nativity and age.

VI. Conclusion

Plant, Woodward, and Tribe suggest that whites with the transition to free-labor were unable to compete with recently freed blacks. Beyond the Civil War itself, the greatest race related conflagration in US history was the 1863 race riots in lower Manhattan, where lower class whites were unwilling to fight to free African-Americans, in part, because they perceived free-blacks as competing with them for low skilled occupations. However, with the transition to free labor, white cumulative net nutrition improved relative to blacks. This study compares changes in the cumulative net nutrition of whites and blacks born before and after slavery and finds that black adult age-related stature loss under bound-labor was greater than whites. However, white net nutrition relative to blacks was better under bound-labor, and white net nutrition compared to other whites was better with the transition to free-labor. African-American

adult age-related stature loss under bound labor was likely due to years of arduous labor associated with degenerative joint disease and environmental insults unique to enslaved blacks and introduces an important area in cumulative net nutrition. By occupations, the across-group difference-in-decompositions illustrates that labor market development and the transition to free-labor benefited whites more than blacks, and Southern white net nutrition was markedly better than Southern blacks under bound-labor. A priori, disparate net cumulative nutritional conditions across ethnic status suggests there should have been greater variation across rather than within groups. However, cumulative net nutrition conditions were greater within-groups, especially by socioeconomic status. Subsequently, with the transition to free-labor, there was greater cumulative net nutrition variation within rather than across-groups and white's cumulative net nutrition improved relative to African-Americans with the transition to free-labor.

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