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**Working Paper**

The Changing Antebellum Period through Early 20th Century  
Net Nutrition between Male and Females: A Difference-In-  
Decompositions within and across Group Comparison

CESifo Working Paper, No. 9402

**Provided in Cooperation with:**

Ifo Institute – Leibniz Institute for Economic Research at the University of Munich

*Suggested Citation:* Carson, Scott A. (2021) : The Changing Antebellum Period through Early 20th Century Net Nutrition between Male and Females: A Difference-In-Decompositions within and across Group Comparison, CESifo Working Paper, No. 9402, Center for Economic Studies and ifo Institute (CESifo), Munich

This Version is available at:

<https://hdl.handle.net/10419/248947>

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## **Impressum:**

CESifo Working Papers

ISSN 2364-1428 (electronic version)

Publisher and distributor: Munich Society for the Promotion of Economic Research - CESifo GmbH

The international platform of Ludwigs-Maximilians University's Center for Economic Studies and the ifo Institute

Poschingerstr. 5, 81679 Munich, Germany

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Editor: Clemens Fuest

<https://www.cesifo.org/en/wp>

An electronic version of the paper may be downloaded

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# The Changing Antebellum Period through Early 20<sup>th</sup> Century Net Nutrition between Males and Females: A Difference-In-Decompositions within and across Group Comparison

## Abstract

A population's average stature reflects cumulative net nutrition and changing long-run economic conditions facing women's economic opportunity, inequality, and net nutrition during development. This study uses stature as a measure for cumulative net nutrition to show how female and male statures varied around the US Civil War. Male statures and net nutrition decreased more than females with industrialization, indicating that women's net nutrition improved relative to men with emancipation and industrialization. The net nutrition of women in agricultural occupations was greater than women in other occupations; however, male stature returns associated with occupations increased more than women with the transition to free-labor.

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

Keywords: nutrition transition by gender, stature by gender, economic transitions.

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## I. Introduction

Changing long-run economic conditions facing women reflects evolving gender roles during economic development and masks cumulative net nutrition that occurs between genders. Household wealth and income are shared resources, and welfare differences between men and women disguise relative economic changes that accrue to women that are separate from other household members. A population's average stature reflects calories consumed, less calories required for work, disease, and to withstand the physical environment, and because stature reflects resources that accrue to individuals within the household, stature better reflects resources available to each household member. Average stature is taller with greater access to nutrition, when food prices are lower, disease environments mild, and resources are distributed more equally (Fogel et al. 1978; Fogel et al. 1979; Carson, 2010, pp. 475-476). Statures are shorter when the opposite is true (Steckel and Floud, 1997, p. 9). With economic development, technology and legal institutions evolve to create greater opportunity for women, changing their economic circumstances, wealth, and net nutrition. Subsequently, before accurate measures for personal income and wealth were developed, statures and biological measures reflect wealth and health conditions that accrue to women within the household (Carson, 2021b; Carson, 2014).

Various factors are related to economic welfare, and stature reflects material well-being that varies with economic and political transitions. Between 1861 and 1865, the US Civil War is the transitional event that signaled a change in female and male cumulative net nutrition that was distinct from conditions facing women, both within the economy and within the household.

Before the War, there was little focus on women's rights and cumulative net nutrition. After the War, suffragettes supported emancipation, formed various women's rights alliances, and sought redress in courts (Lunardini, 1997).

Physical strength is required in developing economies, and men are—on average—stronger, have greater muscle mass per tissue volume, and were employed in physically demanding occupations compared to women (Robb, 1994, p. 222; Marques et al, 2019, p. 151; Bleakley and Costa, 2013, pp. 5-9). In traditional economies, males are primary sources for paid labor market income (Bleakley and Costa, 2013). Developing 19<sup>th</sup> century textile industries used children and women's labor in early manufacturing tasks, and women's smaller physical dimensions and dexterity created occupational advantages for the 19<sup>th</sup> century Northeast's early manufacturing (Besson, 2015, p. 224). However, women were also excluded from labor market opportunities. Social stigma created institutional constraints in developing economies that foreclosed them from white-collar and skilled occupations.

Long-run political and legal institutions also changed during the late 19<sup>th</sup> and early 20<sup>th</sup> centuries, which brought greater political and legal pressure for women's legal standing. In 1869 and 1870, the western territories of Wyoming and Utah were the first to extend voting rights to women (Teele, 2018). In 1872, the Missouri state suffrage leader—Virginia Minor—tried to vote in a Saint Louis County, Missouri election and was refused because of her gender. She took her grievance to the Missouri State Supreme Court, which ruled that voting was limited to men. She appealed the state court's decision to the United States Supreme Court, where *Minor vs. Happersett* affirmed the lower court's decision. Undaunted, early suffrage movements turned their attention to state courts, forming the National American Woman Suffrage Association

(NAWSA) in 1890 that advocated for women's rights. In 1920, the 19<sup>th</sup> Amendment was passed, which secured the right to vote for adults independent of gender.

It is against this backdrop that this study uses United States women and men's stature and differences-in-decompositions to determine how women relative to men's statures born before and after the US Civil War's cumulative net nutrition varied. Two questions are considered. First, how did female and male statures vary before and after the US Civil War? Male statures and net nutrition decreased more than females, indicating that women's net nutrition improved relative to men with emancipation and industrialization. Second, what were the sources of male-female stature variation with the Civil War's transition and did male and female statures vary more across or within gender categories? Women in agricultural occupations were taller than women in other occupations; however, compared to women, male stature returns associated with occupations increased more than women with the transition to free-labor.

## **II. Human Biology and Institutional Change**

A theory for institutional change is essential to understand 19<sup>th</sup> century short-run biological variation by gender. Stature measures the cumulative difference between calories received less calories required for work and other claims from the physical environment, such as disease and inequality (Carson, 2009b; Carson, 2010; Carson, 2013; Carson and Hodges, 2014). Prolonged nutrition restriction over time permanently stunts stature (Mamoboloa, et al, 2005; Carson, 2020). Nonetheless, if environmental insults are short-run in nature, individuals have the capacity to make up for previous short-run privation once more bountiful times return, a process known as catch-up growth (Steckel, 1995; Steckel and Prince, 1997). Stature stunting requires privation to be sufficiently long to permanently alter stature growth, making short-run epidemic disease and other biological disruptions less likely to cause permanent stature

diminution (Haines, Craig, and Weiss, 2003; Carson, 2020; Carson, forthcoming). Long-run institutional change is, therefore, a more likely candidate to explain stature variation than short-run biological disruptions (Carson, 2011c).

Institutions affect resource allocation, and political agents serve as important catalysts that affect economic change (Bush, 1987, pp. 1099-1103; North, 1990; Hodgson, 2009). During 19<sup>th</sup> century Abraham Lincoln and Frederick Douglass were agents for institutional change and economic conditions. Understanding how women's biological conditions changed reflects how property rights were allocated within the household around the time of the US Civil War (Jennings, 1992, p. 132). Abolition and women's suffrage were originally politically tied. However, around the time of emancipation, black men's suffrage took precedence over women's enfranchisement (Moehling and Thomasson, 2020, p. 9). Prior to the 19<sup>th</sup> Amendment—which gave women political enfranchisement—there was greater gender imbalance within the household.

Labor market disruptions around the Civil War was also related to changes in household property rights. As a rule, women within the household place a higher premium on childhood development, and with economic development, men come to realize that giving women greater power within the household increases investments in childhood labor and human capital formation (Doepke and Tertilt, 2009). Returns to childhood labor are low in pre-industrial economies, and the benefits to men of controlling their wife's property offsets the benefits of controlling a spouse's investing in children's and wives' human capital. Nevertheless, it is beneficial with economic progress to allocate greater discretion over children's human capital to mothers (Moehling and Thomasson, 2020, p. 8; Jennings, 1992, pp. 132-133). Therefore, long-



run net nutritional variation was more likely associated with household institutional change than short-run economic and biological disruptions.

### **III. Women and Men's Net Nutrition and Stature**

When other measures for income and material wealth are scarce or unreliable, average stature reflects calories consumed, less the claims required for disease and the physical environment (Steckel and Floud, 1997, p. 9). Furthermore, during economic development, stature growth and skeletal remains are important alternative measures for health. which includes stature, oral health, linear enamel hypoplasia, osteo-arthritis, cribia-orbitalia, parotic hyperostosis, periosteal reaction, and skeletal infections. Poor oral hygiene is associated with infectious disease, dental trauma, and unhealthy diets. Linear enamel hypoplasia occurs when enamel does properly develop, leaving bands of reduced enamel on the tooth's surface, and a relationship may exist between high blood pressure, congested arteries, cardiovascular disease, stroke, and periodontal disease (Taiyet-Ali, Raman, and Vaithilingam, 2000; Sfyroeras, et al 2012). Degenerative joint disease and osteo-arthritis are associated with age and physical activity associated with cartilage and bone loss. Because men were physically more active and in strenuous occupations, males are more likely than women to experience degenerative joint disease and osteoarthritis (Bleakley and Costa, 2013, pp. 5-9). Porotic hyperostosis and cribra orbitalia are nutrition related diseases associated with porous or spongy bone formation within the cranial vault that affects bone formation and are pathological conditions related to bone formation. These conditions exist in contemporary populations but are common for skeletal remains in developing economies (Steckel and Rose, 2002; Steckel et al, 2019).

The Barker Hypothesis is the proposition that poor early life conditions and low prenatal weight increase the likelihood of later life metabolic disorders, which includes obesity, diabetes,

hypertension, hyperlipidemia, and insulin resistance (Barker, 1992). In-utero conditions also reflect mother's net nutrition and health during pregnancy, which is related to cognitive development and later life health of her off-spring (Sørensen et al, 1997, p. 402; Risnes et al, 2011). There is a long planning horizon, but the marginal net benefit of having a child is the increase in household production that results from labor market specialization within the household from having a larger internal labor force. The cost of child is the present value of expected household expenditures plus the explicit cost of raising it (Becker, 1993, p. 305). Mother's net nutrition was also related to household size (Carson, 2012b; Carson, 2014; Komlos and Carson, 2017). Household size increases so long as the expected net benefits of having a child is positive. Because late 19<sup>th</sup> and early 20<sup>th</sup> century households were mostly agricultural, additional household members generally increased household labor forces and agricultural productivity, which provided the household head with a dependable labor force not tied to labor market productivity and market conditions (Atack and Bateman, 1987, pp. 49-70). Subsequently, use of stature by gender reflects dynamic net nutritional variation that occurred during the antebellum period.

#### **IV. Data**

This study considers factors associated with the long-run dynamics between historical female and male stature variation. Ideally, 19<sup>th</sup> and 20<sup>th</sup> century institutions that randomly collected statures would be available for historical stature studies. Such samples, unfortunately, are not available. Military and prison data are two common sources that recorded biological information at the time of measurement. Prison enumerators recorded gender, height, age, occupations, nativity, and complexion. Because inmate records were enumerated at the time of entry, they reflect pre-incarceration conditions and not conditions within prisons. Because

physical characteristics were used to identify inmates in case individuals escaped and were recaptured. Enumerators were thorough when recording inmate characteristics. There are 295,468 males and 7,672 females recorded in US prisons.<sup>1</sup> Women, subsequently, composed around 2.50 percent of 19<sup>th</sup> and early 20<sup>th</sup> prison populations.

Occupation descriptions changed over time, however, are kept sufficiently broad here to maintain occupation similarities. Occupations were recorded in detail, and white-collar workers were physicians, government workers, and the clergy. Skilled workers were blacksmiths, carpenters, and tailors. Agricultural workers were farmers, stock raisers, and dairyman. Unskilled workers were laborers, miners, and cooks. Women were most likely to occupy domestic and unskilled occupations. Skilled women were generally in occupations to serve other women, and there were few female farmers (Goldin, 1990; Bernette, 2013, pp. 306-307). The

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<sup>1</sup> 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 7<sup>th</sup> 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.

most prominent 19<sup>th</sup> century female occupation was domestic laborer, such as cooks and household laborers

Complexions were recorded as white, black, and mulatto. Individuals of African descent were recorded as black, dark black, light black, and Negro. Individuals of European descent were recorded as white, fair, light, medium, and dark. This European complexion category is supported further because individuals claiming birth in Europe but incarcerated in US prisons were recorded with the same white, fair, light, medium and dark complexions. There were individuals of combined African and European ancestry in US prisons. However, in both the federal census and US prison records, until the 1930s, individuals of combined African and European ancestry were recorded as 'mulatto.' However, in the results that follow, individuals of combined African and European ancestry are recorded as 'mixed-race.' There are national and international nativities within the sample. Domestic nativity is classified as from the Northeast, Middle Atlantic, Great Lakes, Plains, Southeast, Southwest, and Far West. International nativity is classified as European and British.

**Table 1, Male and Female Characteristic Distributions for before and after the US****Civil War**

	<i>Pre-1865 Female</i>		<i>Pre-1865 Male</i>		<i>Post-1865 Female</i>		<i>Post-1865 Male</i>	
	N	%	N	%	N	%	N	%
<b>Race</b>								
White	1,940	48.06	105,830	74.56	1,057	29.08	96,776	63.04
Black	1,483	36.74	24,190	17.04	1,450	39.89	31,643	20.61
Mulatto	614	15.21	11,928	8.40	1,128	31.03	25,101	16.35
<b>Ages</b>								
Teens	830	20.56	13,537	9.54	1,034	28.45	27,693	18.04
20s	1,647	40.80	60,060	42.31	1,945	53.51	88,268	57.50
30s	900	22.29	34,174	24.08	525	14.44	29,135	18.98
40s	433	10.73	20,152	14.20	116	3.19	7,335	4.78
50s	166	4.11	10,417	7.34	14	.390	970	.63
60s	61	1.51	3,608	2.54	1	.030	119	.08
<b>Nativity</b>								
<i>International</i>								
Europe	91	2.25	10,940	7.71	16	.44	8,294	5.40
Britain	388	9.61	12,900	9.09	6	.17	2,839	1.85
<i>United States</i>								
Far West	18	.45	2,388	1.68	94	2.59	5,935	3.87
Great Lakes	369	9.14	22,021	15.51	368	10.12	23,339	15.20
Middle Atlantic	2,050	50.78	37,240	26.23	256	7.04	15,271	9.95
Northeast	52	1.29	3,689	2.60	18	.50	1,713	1.12
Plains	172	4.26	8,581	6.05	659	18.13	27,003	17.59
Southeast	766	18.97	36,773	25.91	1,417	38.98	44,383	28.91
Southwest	131	3.24	7,416	5.22	801	22.04	24,743	16.12
<b>Occupations</b>								
White-Collar and Skilled	688	17.04	47,689	33.60	331	9.11	43,785	28.52
Farmers	52	1.29	15,477	10.90	42	1.16	19,119	12.45
Unskilled	2,043	50.61	59,113	41.64	2,572	70.76	76,580	49.88
No Occupation	1,254	31.06	19,669	13.86	690	18.98	14,036	9.14
	4,037	100.00	141,948	100.00	3,635	100.00	153,520	100.00

Source: See footnote 1.

When evaluating 18<sup>th</sup> through 20<sup>th</sup> century statures, four birth categories are considered: women and men born before 1865 and women and men born after 1865. Table 1 separates the sample

by gender, and white males were the largest cohort. However, black and mixed-race women were over half of the female sample composition. Crimes are committed by the young (Freeman, 1999; Gottfredson and Hirshi, 1990, p. 353; Hirschi and Gottfredson, 1983), and teenage proportions increased for both women and men at the turn of the century (Carson, 2008; Carson, 2009). Moreover, the share of women and men in their 20s increased over time. At the end of the century, older individuals decreased as shares of the sample. International nativity for females and males was large during the 19<sup>th</sup> century and decreased as the US developed. Nonetheless, women were a considerably larger proportion of the sample during the 19<sup>th</sup> century. The composition by nativity changed between the 19<sup>th</sup> and 20<sup>th</sup> century, especially by gender. Reflecting general settlement patterns, women and men as a share of the sample from the Far West, Plains, and South increased, whereas shares from the Middle-Atlantic and Northeast decreased with western settlement. Throughout the 19<sup>th</sup> and 20<sup>th</sup> centuries, workers were mostly unskilled. Nevertheless, the share of women who were white-collar workers decreased later in the sample. In sum, women of African descent were larger shares of the sample than white women, and prisons may have developed as institutions of social control over the youth. International immigrants decreased with economic development, while individuals from the Far West, Plains, and South increased as the sample time nativity from the Middle Atlantic and Northeast decreased.

### **III. Regression Section**

Nineteenth and 20<sup>th</sup> century statures by gender were related to race, age, occupations, and nativity. To evaluate female and male net nutrition during economic development, four models are presented: women and men born before 1865 and women and men born after 1865.

$$\text{Cent}_i^j = \alpha^j + \sum_{c=1}^3 \beta_c^j \text{Race}_i + \sum_{a=1}^{13} \beta_a^j \text{Age}_i + \sum_{n=1}^8 \beta_n^j \text{Nativity}_i + \sum_{l=1}^3 \beta_l^j \text{Occupation}_i + \varepsilon_i^j$$

Black and mixed-race dummy variables are included to assess the role between cumulative net nutrition and race. Youth dummy variables are included to account for youth statures by age, and adult age decade dummy variables are included to account for stature loss at older ages. Nativity dummy variables are included for birth within the US, Europe, and Great Britain. Occupation dummy variables are included to account for the relationship between net nutrition and socioeconomic status.

**Table 2, Male and Female Bound and Free Market Regression Models by Demographics  
and Socioeconomic Status**

	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>	<i>Model 4</i>
	Pre-1865 Female	Pre-1865 Male	Post-1865 Female	Post-1865 Male
<b>Intercept</b>	159.60***	170.79***	159.97***	169.24***
<b>Race</b>				
White	Reference	Reference	Reference	Reference
Black	-1.55***	-1.90***	-.355	-1.83***
Mulatto	-.932***	-1.14***	-.919***	-1.57***
<b>Ages</b>				
14	-6.84***	-14.29***	-6.99***	-11.33***
15	-4.23***	-9.76***	-2.40***	-7.73***
16	-3.17***	-6.20***	-2.44***	-4.86***
17	-1.92***	-4.14***	-.843*	-2.95***
18	-1.71***	-2.78***	-.550	-1.80***
19	-1.24**	-1.36***	-.599	-1.11***
20	-1.10**	-.914***	-.515	-.395***
21	-1.59***	-.308***	.271	-.243***
22	-1.44***	.003	.320	-.257***
23-29	Reference	Reference	Reference	Reference
30s	.352	.025	.980***	.150***
40s	-.189	-.280***	-.355	-.160**
50s	.516	-.768***	3.78**	-.463**
60s	-.738	-1.36***	-1.65	-.378
<b>Nativity</b>				
<i>International</i>				
Europe	-4.37***	-2.08***	-.024	-1.74***
Britain	-1.47***	-1.09***	-4.47	-.162
<i>United States</i>				
Far West	2.03	-.002	-.215	2.02***
Great Lakes	1.70***	1.86***	1.58***	1.53***
Middle Atlantic	Reference	Reference	Reference	Reference
Northeast	-.186	.588***	3.31**	.642***
Plains	3.39***	1.63***	1.74***	2.03***
Southeast	2.64***	2.38***	1.67***	2.35***
Southwest	2.42***	3.99***	1.93***	3.41***
<b>Occupations</b>				
White-Collar and Skilled	.891***	-.373***	.698	.937***
Farmers	4.63***	.956***	.091	2.25***
Unskilled	-.060	-.338***	.448	1.19***
No Occupation	Reference	Reference	Reference	Reference



N	4,029	141,948	3,635	153,520
R <sup>2</sup>	.0828	.0856	.0399	.0848

Source: See Table 1.

Table 2 presents estimates for the relationship between race, age, nativity, and socioeconomic status that are used to calculate within and across-group decompositions in the next section. Model 1 is the female stature model for birth before the Civil War. Model 2 is the male stature model for men born before 1865. Model 3 is the female stature model for women born after 1865; Model 4 is the male stature model for post 1865 birth for men.

Female youth stature growth begins and ends earlier than boys, and women encountered less of the observed catch-up growth than boys (Table 2). Throughout the 19<sup>th</sup> and early 20<sup>th</sup> centuries, women and men with darker complexions were shorter than their fairer complexioned counterparts (Steckel, 1979; Carson 2009), and there was a larger stature penalty for darker complexioned men and women born prior to the Civil War (Carson, 2015). During the antebellum period, there was not as much stature loss among adult women relative to men. Men, on the other hand, who were in physically demanding occupations, encountered considerably greater stature loss at older ages (Williams et al., 2019, pp. 288-294). While both women and men listed as farmers had taller statures, female farmer stature premiums were considerably greater than males.

The gender-complexion relationship continued after the Civil War, and black women's stature-complexion penalty was not significant after the transition. The gender-related stature relationship between youth ages and shorter statures persisted, and the male stature advantage was greater after the transition. There were regional patterns that persisted after the antebellum transition, and men from the South and Plains were taller than men born elsewhere within the

US. Women and men from the Plains and South were taller, and European and British women were shorter than women born in the US. Women from the South were similar in stature to women from the Northeast (Carson, 2019b; Carson, 2009a; Prince and Steckel, 2003, pp. 369; Carson, 2017).

#### **IV. Econometric Model**

Differences-in-decomposition models are now constructed for male and female stature differences before and after the post-bellum transition. Partitioning structural and compositional components into treatment and control groups before and after an event is an important technique to evaluate differences associated with returns to characteristics and average characteristics. If there is a significant difference between structural returns before and after an event and only a small difference in compositional effects, the transition is more likely due to the event. On the other hand, if there is a small compositional difference and large structural difference before and after an event a small, while the compositional difference is large, response variable differences are less likely caused by the event and more likely due to differences-in-decompositions (Carson, 2021a).

Separating female-male net nutritional differences into control and treatment groups before and after antebellum birth isolates gender return differences into returns to characteristics and average characteristics. The general framework for treatment and control models is expressed in vectors. Let  $y_c$  and  $y_t$  be treatment and control models expressed in vectors.

$$y_c = \alpha_c + \beta_c X_c \quad (1)$$

$$y_t = \alpha_t + \beta_t X_t \quad (2)$$

where  $\alpha_c$  and  $\alpha_t$  are the control and treatment group autonomous stature components.  $\beta_c$  and  $\beta_t$  are control and treatment response variable sensitivities with respect to structural characteristics.  $X_c$  and  $X_t$  are control and treatment average compositional matrices. Birth before and after 1865 are the event associated with the transition to ante-bellum net nutrition, and females and males are the entity effects associated with the transition.

$$Cent_f^{pre} = \alpha_f^{pre} + \beta_f^{pre} X_f^{pre} \quad (3)$$

$$Cent_f^{post} = \alpha_f^{post} + \beta_f^{post} X_f^{post} \quad (4)$$

$$Cent_m^{pre} = \alpha_m^{pre} + \beta_m^{pre} X_m^{pre} \quad (5)$$

$$Cent_m^{post} = \alpha_m^{post} + \beta_m^{post} X_m^{post} \quad (6)$$

where  $\alpha_f^{pre}$  and  $\alpha_f^{post}$  are antebellum and post bellum female autonomous stature components.

$\alpha_m^{pre}$  and  $\alpha_m^{post}$  are antebellum and post bellum male autonomous stature components.  $\beta_f^{pre}$  and  $\beta_f^{post}$  are antebellum and post bellum female stature returns with characteristics, while  $\beta_m^{pre}$  and  $\beta_m^{post}$  are antebellum and post bellum male stature returns.  $X_f^{pre}$  and  $X_f^{post}$  are antebellum and post bellum matrices, while  $X_m^{pre}$  and  $X_m^{post}$  are similar characteristics for antebellum and post bellum average male characteristics.

There are two approaches to evaluating structural and compositional effects between groups: within-groups and across-groups. The within group decomposition partitions the difference into response variables within genders before and after 1865 birth. The across-group decomposition partitions the male and female stature difference across genders for birth before and after 1865. Unlike the difference-in-difference estimator, decompositions are first

decomposed, and the decompositions are differenced, associated with differences that are not the same as for differences-in-difference estimator (Wooldridge, 2010, p. 410).

## V. Within and Across Group Estimators

One approach to infer causal relationships in the quasi-experimental literature is the difference-in-difference estimator, which postulates causal inference using only cross-sectional data. Difference-in-decomposition estimation separates response variable effects into returns to characteristics and average characteristics around the time of an event using within and across-group differences using Oaxaca decompositions.

### 6.1 Within-Group Decompositions

Within-group decompositions isolate male-female response variable differences into post and pre-antebellum period male and female stature variation. The within-group gender decomposition is calculated by first taking the stature difference within-genders before and after the Civil War. A second difference is taken between these male and female within-group differences. Because males are taller than females, males are assigned the base category (Gray and Wolfe, 1980; Frayer and Wolpoff, 1985).

Equation 7 is the within-group difference-in-decompositions between males and females at post-bellum characteristics and antebellum returns to characteristics.

$$\begin{aligned} (Cent_m^{post} - Cent_m^{pre}) - (Cent_f^{post} - Cent_f^{pre}) &= (\alpha_m^{post} - \alpha_m^{pre}) - (\alpha_f^{post} - \alpha_f^{pre}) + \left[ (\beta_m^{post} - \beta_m^{pre}) \bar{X}_f^{post} - (\beta_f^{post} - \beta_f^{pre}) \bar{X}_m^{post} \right] \\ &+ \left[ (\bar{X}_m^{post} - \bar{X}_m^{pre}) \beta_f^{pre} - (\bar{X}_f^{post} - \bar{X}_f^{pre}) \beta_m^{pre} \right] \end{aligned} \quad (7)$$

Equation 8 is the within-group difference-in-decomposition stature estimate for antebellum average characteristics observed at postbellum returns to characteristics.

$$\begin{aligned} (Cent_m^{post} - Cent_m^{pre}) - (Cent_f^{post} - Cent_f^{pre}) &= (\alpha_m^{post} - \alpha_m^{pre}) - (\alpha_f^{post} - \alpha_f^{pre}) + [(\beta_m^{post} - \beta_m^{pre}) \bar{X}_f^{pre} - (\beta_f^{post} - \beta_f^{pre}) \bar{X}_m^{pre}] \\ &+ [(\bar{X}_m^{post} - \bar{X}_m^{pre}) \beta_f^{post} - (\bar{X}_f^{post} - \bar{X}_f^{pre}) \beta_m^{post}] \end{aligned} \quad (8)$$

If component values in Equations 7 and 8 are positive, the male post-bellum stature difference is greater than females and negative if the female post-bellum stature difference is greater than males.

## 6.2 Across-Group variation

The across-group difference-in-decompositions isolates male-female stature response variables as the difference between males and females across post and pre-antebellum periods. The across-group decomposition is calculated by first taking the stature difference across genders before and after 1865. A second difference is taken between the post and antebellum periods. Equation 9 is the across-group difference-in-decomposition at female returns to characteristics and average male characteristics.

$$\begin{aligned} (Cent_m^{post} - Cent_f^{post}) - (Cent_m^{pre} - Cent_f^{pre}) &= (\alpha_m^{post} - \alpha_f^{post}) - (\alpha_m^{pre} - \alpha_f^{pre}) + [(\beta_m^{post} - \beta_f^{post}) \bar{X}_m^{post} - (\beta_m^{pre} - \beta_f^{pre}) \bar{X}_m^{pre}] \\ &+ [(\bar{X}_m^{post} - \bar{X}_f^{post}) \beta_f^{post} - (\bar{X}_m^{pre} - \bar{X}_f^{pre}) \beta_f^{pre}] \end{aligned} \quad (9)$$

Equation 10 is the across-group difference-in-decompositions for male returns to characteristics and average female characteristics.

$$(Cent_m^{post} - Cent_f^{post}) - (Cent_m^{pre} - Cent_f^{pre}) = (\alpha_m^{post} - \alpha_f^{post}) - (\alpha_m^{pre} - \alpha_f^{pre}) + [(\beta_m^{post} - \beta_f^{post}) \bar{X}_f^{post} - (\beta_m^{pre} - \beta_f^{pre}) \bar{X}_f^{pre}]$$

$$+ \left[ \left( \bar{X}_m^{post} - \bar{X}_f^{post} \right) \beta_m^{post} - \left( \bar{X}_m^{pre} - \bar{X}_f^{pre} \right) \beta_m^{pre} \right] \quad (10)$$

Component values are positive if male post-bellum returns to characteristics are greater than female post-bellum returns to characteristics and negative if female post-bellum returns are greater than male characteristics.

### **VIII. Female and Male Stature Returns and Average Characteristics: A Difference-in-Decompositions Approach**

## 8.1 Male-Female Within Group Decompositions

Table 3, Male-Female Within-Group Stature Difference-within-Decompositions

<i>Panel A</i>				
<b>Males</b>	$(\beta_M^{Post} - \beta_M^{Pre}) \bar{X}_M^{Post}$	$(\bar{X}_M^{Post} - \bar{X}_M^{Pre}) \beta_M^{Pre}$	$(\beta_M^{Post} - \beta_M^{Pre}) \bar{X}_M^{Pre}$	$(\bar{X}_M^{Post} - \bar{X}_M^{Pre}) \beta_M^{Post}$
	<i>Structure</i>	<i>Composition</i>	<i>Structure</i>	<i>Composition</i>
Levels				
Sums	-0.084	.427	-.103	.447
Total		.343		.343
Proportions				
Intercept	-4.51		-4.51	
Race	-.209	-.486	-.107	-.588
Ages	.607	-.636	.539	-.568
Nativity	.094	2.35	.236	2.21
Occupations	3.78	.017	3.55	.249
Sum	-.245	1.25	-.301	1.30
Total		1		
<i>Panel B</i>				
<b>Females</b>	$(\beta_F^{Post} - \beta_F^{Pre}) \bar{X}_F^{Post}$	$(\bar{X}_F^{Post} - \bar{X}_F^{Pre}) \beta_F^{Pre}$	$(\beta_F^{Post} - \beta_F^{Pre}) \bar{X}_F^{Pre}$	$(\bar{X}_F^{Post} - \bar{X}_F^{Pre}) \beta_F^{Post}$
Levels				
Sums	.999	1.10	1.20	.901
Total		2.10		2.10
Proportions				
Intercept	.176		.176	
Race	.229	-.114	.210	-.094
Ages	.324	-.143	.315	-.134
Nativity	-.392	.824	-.208	.640
Occupations	.138	-.042	.079	.017
Sum	.475	.525	.572	.428
Total		1		1
<i>Panel C</i>				
<b>Difference in Decompositions</b>				
Levels				
Sums	-1.08	-.677	-1.31	-.454
Total		-1.76		-1.76
Proportions				
Intercept	-4.69		-4.69	

Race	-.438	-.373	-.317	-.494
Ages	.283	-.493	.225	-.434
Nativity	.486	1.53	.443	1.57
Occupations	3.64	.060	3.47	.232
Sum	-.719	.719	-.873	.873

Source: See Table 1.

### 8.1.1. Male within-group Decompositions

The male level within-group decomposition is positive, indicating that male net nutrition improved for birth after 1865, and the negative autonomous male stature component indicates that independent of characteristics, males were taller prior to the transition (Table 3, Panel A). However, characteristic sources are important for the male transition to the post-bellum period. By proportion, men's within-group stature difference was explained the most by average characteristic differences, and men born after 1865 had better cumulative net nutrition with a change in average characteristics. Furthermore, male stature returns and average characteristics by race were greater prior to emancipation. Age-stature returns were greater for post-bellum males; however, returns to average male characteristics were higher during the antebellum period. Male stature returns by nativity and average characteristics were greater after 1865 birth, and returns by male socioeconomic status had the greatest return among characteristics, indicating that male net nutrition improved with the transition to free-labor.

### 8.1.2. Female within-group Decompositions

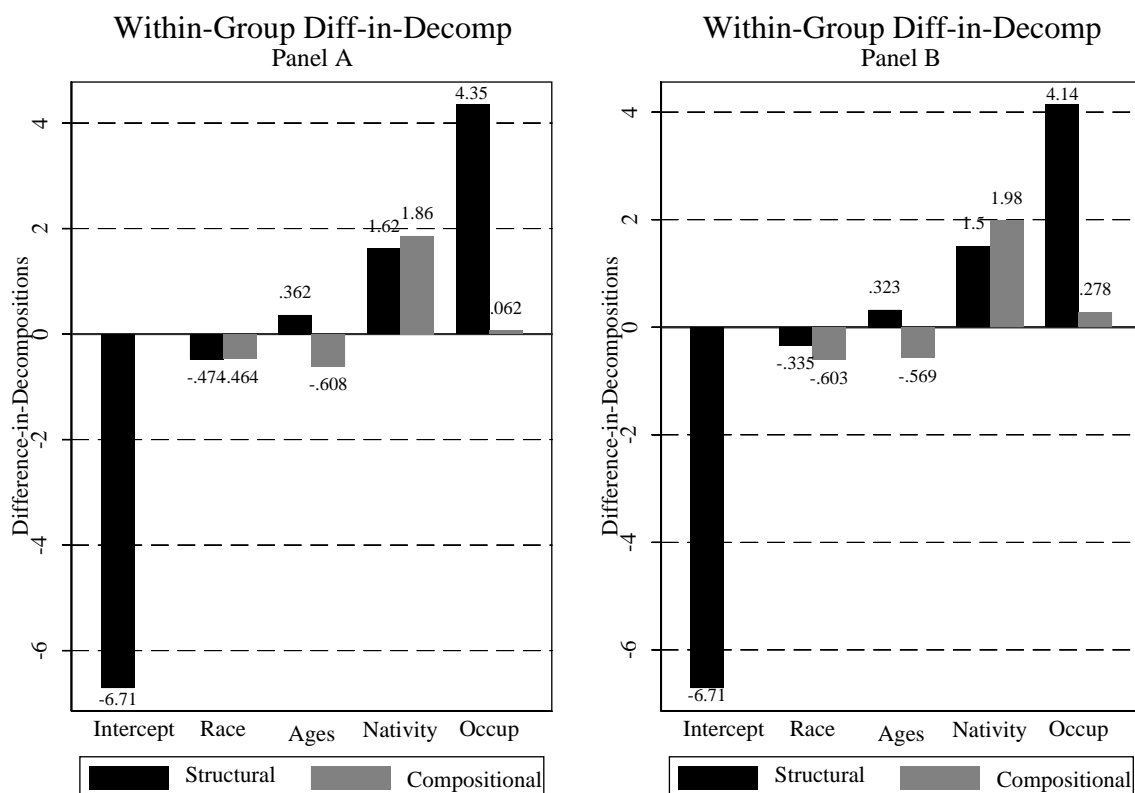
The female level within-group Oaxaca decomposition is positive, indicating that female net nutrition improved after the antebellum transition (Table 2, Panel 3). Nonetheless, the source of women's stature advantage after the transition was important. By proportion, women's ages were the greatest source of women's post-bellum net nutrition advantage. After the transition,



women's returns to race were also larger than the ante-bellum period. Nevertheless, for both ages and race, women had greater net nutrition associated with average characteristics before the transition. Furthermore, women's within-group returns to nativity stature advantage was greater before the transition, and women's antebellum regional stature advantage was greater in the Plains and South (Carson, 2018; Carson, 2019; Prince and Steckle, 2003, p. 369). Women's returns to socioeconomic status were also greater after the transition, indicating that female net nutrition also improved with the transition to free labor.

### **8.1.3. Within Group Male-Female Difference-in-Decompositions**

Partitioning male and female within-group stature differences with the net nutrition transition illustrates how net nutrition varied within-groups for birth before and after 1865. Table 3's Panel A is the male within-group decomposition. Panel B is the female within-group decompositions. Panel C is the male-female within-group difference-in-decompositions with the net nutrition transition. The sign and magnitudes demonstrate how male within-group variation changed with the transition. For example, a positive intercept difference indicates that men's within-group net nutrition was greater after the transition, whereas a negative intercept indicates that women's cumulative net nutrition difference was greater with the transition to free-labor.



**Figure 1, Male-Female, Within-Group Difference-in-Decompositions**

Among the most far-reaching net nutritional relationships is socioeconomic status, and women born before 1865 recorded as agricultural workers were significantly taller than women in other occupations. However, where females in agricultural occupations born before 1865 were taller than women in other occupations, female agricultural workers had no stature advantage relative to women in other occupations, female agricultural workers had no stature advantage relative to women in other occupations for women born after 1865. Table 2 also indicates that stature growth for male agricultural workers was greater than males in other post 1865 occupations. It was male statures by occupation that changed appreciably after 1865 birth, and male agricultural workers born after the transition were considerably taller than male workers in other occupations.

Nativity for men born after 1865 also had a greater effect than for men born before 1865. Women's stature advantage for birth in the South and Plains decreased (Table 2), and for women born after 1865—except for women born in the Far West—there was little stature advantage. It was male's birth stature advantage by region that increased after the 1865 transition. Both before and after the antebellum transition, women and men native to Britain and Europe were shorter than women and men native to America's Northeast and United States. For both males and females, stature by age increased for birth after the transition (Tables 2 and 3). Stature varied by complexion, and women born before 1865 with darker complexions were associated with significantly taller statures compared to darker complexioned women after the transition. Results for men by complexion are mixed, yet darker complexioned males were shorter than fairer complexioned males throughout, which challenges the social preference explanation for shorter statures for darker complexioned males prior to emancipation because of social preferences that disproportionately favored individuals with fairer complexions (Bodenhorn, 2002; Carson, 2015).

Catch-up growth is the biological phenomenon where children deprived of net-nutrition in adolescence receive insufficient calories before adult terminal stature growth can return to their genetically determined stature growth if sufficient calories offset early calorie deficits. Moreover, because of sexual dimorphism, young female's stature growth begins and ends 18 months before males. Table 2 and 3 illustrates that nutrition for both post and antebellum young girls in the early teens began earlier than boys. However, males were, on average, taller, and their height advantage relative to women increase after the transition to free labor.

## 8.2 Male-Female Across-group Decompositions

Male and female stature variation across genders illustrates the difference between genders with the antebellum net nutrition transition (Table 4). Panel A is the male-female post-bellum across group stature difference. Panel B is the male-female antebellum across-group stature difference. Panel C is the male-female across-group difference-in-decompositions

**Table 4, Male-Female Across-Group Stature Difference-within-Decompositions**

<i>Panel A</i>				
<b>Post 1865 Birth</b>	$(\beta_M^{Post} - \beta_F^{Post}) \bar{X}_M^{Pos}$	$(\bar{X}_M^{Post} - \bar{X}_F^{Post}) \beta_F^{Pos}$	$(\beta_M^{Post} - \beta_F^{Post}) \bar{X}_F^{Pos}$	$(\bar{X}_M^{Post} - \bar{X}_F^{Post}) \beta_M^{Pos}$
	<i>Structure</i>	<i>Composition</i>	<i>Structure</i>	<i>Composition</i>
Levels				
Sums	9.55	.257	8.97	.832
Total		9.80		9.80
Proportions				
Intercept	.946		.946	
Race	-.044	.025	-.086	.066
Ages	-.053	.024	-.073	.044
Nativity	.053	-.028	.070	-.044
Occupations	.072	.005	.058	.019
Sum	.974	.026	.915	.085
Total		1		1
<i>Panel B</i>				
<b>Pre 1865 Birth</b>	$(\beta_M^{Pre} - \beta_F^{Pre}) \bar{X}_M^{Pre}$	$(\bar{X}_M^{Pre} - \bar{X}_F^{Pre}) \beta_F^{Pre}$	$(\beta_M^{Pre} - \beta_F^{Pre}) \bar{X}_F^{Pre}$	$(\bar{X}_M^{Pre} - \bar{X}_F^{Pre}) \beta_M^{Pre}$
Levels				
Sums	10.11	1.46	10.29	1.28
Total		11.56		11.56
Proportions				
Intercept	.968		.968	
Race	-.007	.032	-.014	.039
Ages	-.017	.026	-.032	.041
Nativity	.011	.017	.003	.025
Occupations	-.081	.052	-.035	.005
Sum	.874	.126	.890	.110
Total		1		1
<i>Panel C</i>				

<b>Difference in Decompositions</b>				
Levels				
Sums	-.558	-1.20	-1.31	-.446
Total		-1.76		-1.76
Proportions				
Intercept	-.022		-.022	
Race	-.037	-.008	-.071	.027
Ages	-.036	-.002	-.041	.003
Nativity	.042	-.044	.067	-.069
Occupations	.154	-.046	.093	.014
Sum	.100	-.100	.026	-.026

Source: See Table 1.

### 8.2.1 Male -Female Across-Group Post Bellum Stature Returns

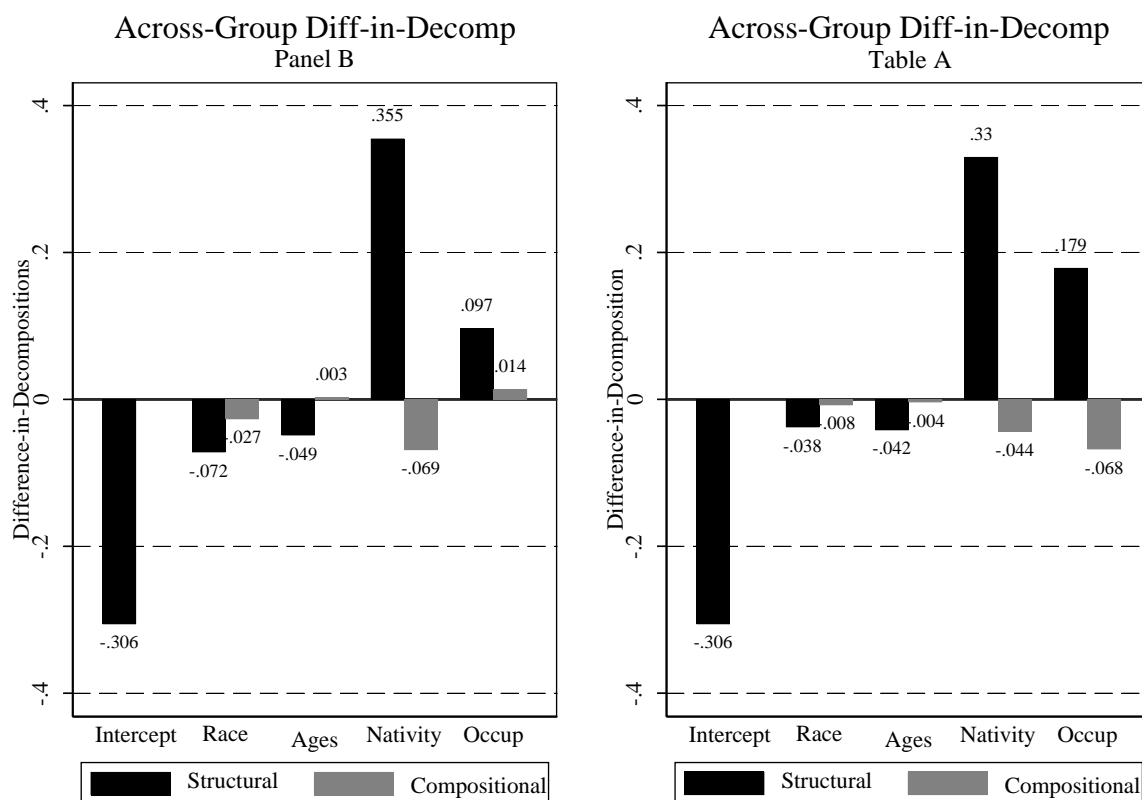
Across-group decompositions illustrate males were taller than females after the transition to free-labor. The majority of male-female stature differences were genetic, and stature differences are genetic. Nevertheless, the source of post-bellum male-female stature difference is important. The bound-labor female race and age stature difference associated with returns to characteristics was greater than males, and the post-bellum returns to average male characteristics offset most of the stature returns to nativity and age. Post 1865 male stature returns to nativity and occupations were greater than females, and the returns to average nativity and occupation differences were small, indicating that most of the male stature returns were associated with returns to characteristics. In sum, most of the post-bellum male stature returns were associated with returns to characteristics and only a small proportion explained by returns to average characteristics.

### 8.2.2 Male-Female Across-Group Antebellum Stature Returns

The male-female bound-labor across-group decompositions indicate that males were

taller than females before the transition. Nevertheless, the source of the antebellum male-female stature returns is important. As with post-bellum male-female stature differences, ante-bellum female stature returns to characteristics were greater than males. However, the antebellum stature returns to average male characteristics was considerably larger than antebellum female returns to characteristics. Like post-bellum nativity effects, males had greater stature returns associated with nativity; however, the stature difference associated with average male-female characteristics was smaller. The occupations stature returns differences were greater for females than males. In sum, most of the antebellum male stature return advantage was associated with returns to characteristics, with only a small portion explained by returns to average characteristics.

### 8.2.3 Across-Group Difference-in-Decompositions



**Figure 2, Male-Female, Across-Group Difference-in-Decompositions**

Panel C illustrates the male-female, bound-free labor percent differences were associated with returns to characteristics and average characteristics. Because biological sexual dimorphism is among the most noted stature differences, gender differences were smallest with the transition to free-labor. Male stature returns associated with occupations and nativity were greater after the transition to free-labor. Female gender-based antebellum stature advantages were greater than males associated with age and race. Consequently, because of sexual-dimorphism, gender was a small proportion of the stature difference with the transition to free-labor, and occupations and nativity were the greatest source of gender-based stature differences.

## IX. Conclusion

Changing long-run economic conditions for women reflect changing gender roles during economic development. Women's early economic and net nutritional conditions were tied to household wealth, which masks net nutrition that accrues to women. Household wealth and income are shared resources, which disguises net nutrition that accrues to women from other household members. This study evaluates late 19<sup>th</sup> century and early 20<sup>th</sup> century male-female across and within group statures with differences-in-decompositions. Across male and female differences-in-decompositions, socioeconomic status has the most far-reaching relationships with stature differences, and before 1865 birth, women in agricultural occupations were significantly taller than women in other occupations. The male stature advantage associated with region increased the most with the transition to free labor. For both periods, British and European men and women were shorter relative to their native-born counterparts. The male-female within-group difference-in-decompositions indicates, little difference is due to sexual dimorphism, and occupations and nativity are the greatest source of the within-group stature difference-in-decompositions. The male-female across-group difference-in-decompositions indicates male stature returns associated with socioeconomic status and nativity were greater after the transition, and females' net nutrition associated with age and race relative to men increased with the transition. Subsequently, the male-female within and across group differences with the transition to free-labor were similar, and women's stature differences were the greatest source of nutrition variation.



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