# A Substitution Effect as a Possible Cause for the Antebellum Heights Conundrum.

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**Abstract**

The first half of the nineteenth century was a time of significant economic growth in the United States. Economic growth generally coincides with increasing real wages and better health and nutrition. It is also common to see increasing stature of a nation over time as a result of economic development. Ironically, the antebellum period was a time of decreasing average stature. This contradiction is referred to as the antebellum puzzle. The literature regarding this puzzle offers some possible explanations. We focus on one possible hypothesis for the antebellum puzzle. Changes in Nutrition and Diet may have resulted from a transformation in the composition of US economic production leading to a temporary decrease in overall stature. This paper examines if there was a substitution effect between manufactured goods and agricultural output as the US developed during the antebellum period. Because of the lack of data about nutrition during the 1800s, stature is used as a proxy to reflect one's diet in the early stages of life. Our research finds that a substitution effect between manufactured goods and agriculture output may have contributed to the antebellum puzzle.

# 1 Introduction

Reliable statistics about consumption patterns, real wages, and household income are not readily available to study the standard of living in the United States during the nineteenth century. An alternative methodology is to use stature as a measure of welfare. This paper contributes to the relatively new approach of utilizing anthropometric data as a proxy for a populations standard of living.

The increasing height of a population is positively correlated with economic development. However between 1830 and 1860, the average height of the US population was declining despite rising incomes. This contradiction is known as the antebellum puzzle. There certainly are deleterious consequences associated with economic development. For example, urbanization and an increase in immigration results in the spread of communicable diseases. Another ramification is environmental degradation. Such factors are impediments to ones physical growth potential.

In the following analysis, we focus on another explanation for the antebellum puzzle. Changes in nutrition and diet may have resulted from a transformation in the composition of US economic production leading to a temporary decrease in overall stature. Komlos (1987) argues that the reason for the decrease of stature during the antebellum period was a result of a decrease in nutritional intake. This is because agricultural production was not able to keep up with the growing demand for food during economic expansion and urbanization. The labor supply and productivity in the agricultural sector did not increase nearly as fast as the demand for the production food.

In addition, food became less accessible as the result of industrialization. As urban areas developed, the distance from farms to city centers increased. As a result, the cost of transporting food increased. Consequently, the price of food was driven up and, thus, food consumption decreased. For example, grain prices increased 30 percent between the 1820s and 1850s and meat prices increased 22 percent compared to industrial goods. The increases in food prices prompted people to reduce their food consumption. Unfortunately, the harmful consequences were not known at that time (Komlos, 1987).

Even people whose income increased along with food prices probably also decreased their food consumption. Because the price of food was increasing relative to industrial goods, even wealthy individuals substituted commodities in place of food (Komlos, 1987). As we will see in our regression models, even farmer's heights decreased during this time. This is contrary to what we would expect because of their easy access to food. One possible expla-

nation may be that farmers sold more of their output at this time to take advantage of the rising prices. This paper examines if there was in fact a substitution effect between manufactured goods and agricultural output as the US developed during the antebellum period.

## 2 Average Height as a Proxy for National Welfare

Since the 1700s, economists have searched for an accurate measure of welfare. The subject of national accounting became an important topic in the 1930s because of the Great Depression. Economists such as Simon Kuznets, Joseph Davis, and Merril K. Bennet wanted a method to indicate the level of consumer satisfaction. Kuznets proposed to include non-market activities, occupation costs, leisure, costs of urban civilization, and inequality.

Gross National Product soon became the standard measure of welfare despite its deficiencies. Using statistics such as census data and market prices, economic historians were able to construct GNP for the years as far back as the middle of the 19th century for several countries. Because these time series were not very detailed and were questionable in many regards, they were not considered an accurate measure of welfare (Steckel, 1995).

In the 1950s, the United Nations created several indices to make it easier to compare countries' standards of living. Not until the 1970s did physiologists, nutritionists, and anthropologists begin to use stature to measure health standards. By the end of the 1970s, international organizations and development economists also began using stature to make international comparisons (Steckel, 1995). Anthropometrics is a relatively new method of estimating someone's health and diet. Various measurements can be used to represent one's total nutritional status. For example, birth weight reflects one's nutritional situation at the time of birth. In addition, height at maturity can be used as a measurement of cumulative net nutrition. This implies that height reflects the nutritional intake of a person throughout all of the growing years. The nutritional status of an entire population is important to study since it influences mortality rates, fertility rates, labor productivity, and demographic trends. Also, before the 20th century, food consumption consisted of a larger percentage of total expenditure. Thus, height fluctuations can be examined to study trends in the standard of living (Komlos, 1987).

From the time of birth until the time of maturity, the growth process can be dichotomized into two periods. Height increases quickly during infancy, but the rate of growth slows throughout childhood. Once adolescence is

reached, however, the rate of growth again becomes very rapid. After the growth rate peaks, it begins to decline until it becomes zero at this point of physical maturity. Girls begin adolescence two years earlier than boys. As a result, they are initially taller at this time. Although, boys begin to grow taller at the same time, their growth rate is less than that of girls. Because boys have two additional years of growth, the average height of males is greater than females at maturity (Steckel, 1995).

Height is a function of genetics and the condition of one's environment especially during growth periods. When comparing two populations from different geographical locations, stature differentials are almost always the result of environmental issues. One exception is in Asian countries where genetics are the primary cause of smaller average heights. Richard Steckel (1995) explains that stature reflects the impact of diet, disease, and intensity of work during one's growing years. In addition, Steckel also describes that height "is a measure of the consumption of basic necessities that incorporates demands placed on one's biological system" (p. 1908).

Only within the last few decades has it been shown that average nutritional status is closely related to anthropometric statistics. In capitalist economies, the mean stature of children and adults can be used to approximate family income since there is a positive relationship between food consumption and real income. Furthermore, Komlos (1987) argues that stature is a "better proxy of the standard of living during the early stages of industrialization than any other measure hitherto devised" (p. 1154).

A poor diet makes an individual more susceptible to disease. Furthermore, the interaction of malnutrition and disease will further stunt someone's growth development. Children are especially vulnerable to this process. There is also a direct relationship between height and socio-economic status, especially in industrial countries. In addition to better nutrition, a higher income reflects a less physically demanding occupation, increased access to healthcare, and better housing conditions. However, there are limits to this factor. After attaining growth capacity, any improvement in caloric consumption becomes marginal. Thus, people who grew up in very wealthy families are not necessarily going to be incredibly tall (Steckel, 1995).

## 2.1 Stature Fluctuations in the 19th Century

The secular trend of stature in the US has been upward since colonization. However, a cyclical pattern occurred in the mid-1800s where heights actually declined. Although heights were decreasing during the antebellum period, surprisingly the US economy was expanding at the same time. Komlos

(1987) explains that "between 1840 and 1870 per capita net national product increased by more than 40 percent and value added in the agriculture sector was growing between 2.3 and 4.2 percent per annum in the 1840s and 1850s" (p.898). With an economic expansion, nutrition and food intake is expected to increase. However, empirical evidence throughout the literature about this subject shows nutritional stature decreasing despite economic prosperity.

For white males born between 1720 and 1740, average height tended to be between 171 and 172 centimeters. By 1750, the average height was closer to 173 centimeters followed by a relatively more consistent average of 172.5-173.5 centimeters for those born between 1780 and 1830. For the birth years between 1830 and 1870, the average heights of white army recruits fluctuated downward. This trend bottomed out in the 1880s at 169-170 centimeters and has continued upward ever since (Steckel 1995, p.1920). The decreases in the average heights of adolescents also show this pattern. Teens born in the 1840s averaged five centimeters less than those born between 1825 and 1830 (Steckel 1995, p.1921).

## 2.2 Stature Differentials by Geographic Region

In addition to height fluctuations over time, the literature also frequently comments on height differences between states and regions. Even during the American Revolution, the height difference between Northerners and Southerners is apparent. Southerners were 0.8 centimeters taller than those from New England states. A study by John Komlos (1997) concludes that West Point cadets who were recruited from the South in the middle 1800s were approximately one percent taller than cadets from the Middle Atlantic and Western regions. Komlos notes that the height decline of the antebellum period occurred even though there was a western migration from the Northeast to a climate more suitable for biological growth.

Margo and Steckel (1992) analyze amnesty oath records signed by Southern whites in the 1960s. Margo and Steckel found that people from the interior states of Kentucky, Tennessee, Missouri, and Arkansas were between 0.8 to 1.8 centimeters taller than those from the lower coastal states of Alabama, Louisiana, South Carolina, and Texas.

In the Northeast region of the US, incomes were relatively high while this region also had the lowest average height. The Northeast had the worst farmland compared to the South and Midwest. As a result, the Northeast's comparative advantage evolved into manufacturing. Industrialization drove down the supply of food and drove up the price of food relative to that of

other goods. While this appears to imply that urbanization caused a decrease in average height, after further urbanization at the end of the 19th century and throughout the 20th century, average heights increased. Furthermore, decreases in stature primarily occurred in urban areas. During the antebellum period, most of the US population resided in rural areas and height differences between farmers and city dwellers were very small. In 1830, only six percent of Americans lived in cities with a population greater than 10,000. By 1860, the percentage increased only to 14.8 (Steckel, 1995).

### 2.3 Stature Differentials by Occupation

Another characteristic of the 19th century is the significant height differentials between occupational cohorts. The differences were much more apparent during this time compared with the late colonial period or the 20th century (Steckel, 1995). Comparing stature by occupation is a method of analyzing inequality. According to Margo and Steckel (1983), union army recruits whose civilian occupation was farming were 0.4 centimeters taller than white-collar workers were. In turn, white-collar workers were 0.8 centimeters taller than laborers.

Komlos's comparison of West Point cadets found that the average height of cadets from low-income families was less than those coming from relatively high-income families. In addition, he found a positive correlation between income and socioeconomic occupations. The cohort with relatively high socioeconomic jobs experienced a decrease in average height starting in the 1850s. This trend began later compared to those with less prestigious occupations (Komlos, 1987).

## 3 Theoretical Model

Using height statistics of white union army soldiers, we compare trends between the Northeast and Midwest during the antebellum period. Our regression model emulates that of Margo and Steckel (1983), Nicholas and Steckel (1990), and Steckel (1995). Data describing stature and other characteristics of white soldiers were available from the Civil War muster rolls. Regression analysis is used to compare stature differentials of army soldiers between regions. The proposed model correlates height with region of birth, year of birth, and civilian occupation.

In addition, we create a variable that tests whether a substitution effect could have caused the average height of US born army soldiers to decline

during the antebellum period. The variable that reflects the agricultural-manufactured goods substitution effect is reffered to as the Relative Price Index (RPI).

The empirical regression model thus formulated is given as follows::

$$stature = \beta_0 + \beta_1\ farmer + \beta_2\ professional\ 1 + \beta_3\ Professional\ 2$$
$$+\beta_4\ artisan + \beta_5\ service + \beta_6\ manual + \beta_7\ unproductive$$
$$+\beta_8\ agricultural\ worker + \beta_9\ born\ in\ mw$$
$$+\beta_{10}\ Born\ 1826 - 1830 + \beta_{11}\ Born\ 1831 - 1835 + \beta_{12}\ Born\ 1836 - 1843$$
$$+\beta_{13}\ RPI + \epsilon$$

where the variables are explained in Table 1.

Table 1: Model Variables

| **Variable** | **Description** |
|---|---|
| stature | Height of the union army recruit; |
| RPI | relative price index; |
| professional 1 | manufacturers, teachers, lawyers, and other professional workers; |
| professional 2 | clerks, merchants and salesmen; |
| artisan | skilled labor including blacksmiths, carpenters, and masons; |
| service | service workers including assistants, spinners, and policemen; |
| unproductive | includes those who are not involved in paid work i.e. retirees, students; |
| agricultural worker | hired farm workers; |
| born in MW | the army recruit was born in the Midwest; |
| Born 1826-1830 | the army recruit was born 1826-1830; |
| Born 1831-1835 | the army recruit was born 1831-1835; |
| Born 1836-1843 | the army recruit was born 1836-1843; |
| $\epsilon$ | disturbance term; |

$\beta_0$ through $\beta_{13}$ are the parameters in the model to be estimated.
Only those who are born in the northern region or the Midwestern region of the US are included. Therefore there is not a variable that reflects migrants in this model. Those who are born before 1826 and are 18 years old or older are reflected in $\beta_0$, the intercept. Those born after 1843 are not included in

the model. The RPI is a price index of manufactured goods divided by a price index of agricultural goods:

$$RPI = \frac{P(manufacturedgoods)}{P(agriculturalgoods)}$$

The assumption is that as the price of manufactured goods increases relative to the price of agricultural output, people will eat more food. In a developing country, more food consumption will contribute to the average height of the population over time. In contrast, if the price of food increases faster than the price of manufactured goods, then the population will begin to consume larger amounts of manufactured products relative to agricultural products. In this second scenario we posit that over time people will not grow as tall as in previous generations. Hence, we may have a possible explanation to the antebellum puzzle.

# 4 Data Collection

Information about army recruits were taken from the database "Aging of Veterans of the Union Army: Military, Pensions, and Medical Records, 1820-1940" (Fogel, 2000). Prices statistics were taken from Wholesale commodity prices in the United States, 1700-1861 (Cole, 1938). The index of this book includes monthly averages of several products for various US cities during the antebellum period. However, only three of the cities were applicable to this research: Cincinnati, New York City, and Pittsburgh.

Prices of agricultural output and prices of manufactured goods were averaged in order to create a prices index for both types of products. In order to create a price index that reflected price sensitivity to stature determination, another annual index was created. Therefore, price indexes were created that included prices from several years. These price indexes include the prices of manufactured and agricultural goods for the time periods t = -1, 1, 6, 7, 12, and 13; where t = 0 is the army soldiers birth year. These years represent when an individual's stature is most sensitive to food consumption. The variable RPI was created with the two price indexes. Our hypothesis is that as the relative price of one composite good increases, we expect the quantity demand of the other composite good to increase. Hence, we expect the following relationship to hold:

$$\sum_{i-1}^{n} \sum_{t-1}^{T} stature_{it} = f\frac{Price\ Index\ of\ Manufactured\ Goods}{Price\ Index\ of\ Agricultural\ Goods}$$

where $i$ is the $i^{th}$ soldier born at time $t$.

## 5 Evidence and Implications of the Model

In this section, we analyze our model the variable RPI and compare it to a model without this variable. The soldiers included in both sample were born and enlisted in the same state. However, the second regression model includes soldiers only in the states that we had price statistics for: Pennsylvania, Ohio, and, New York. As a result, the sample size decreased to 1,751. The relative price index has a coefficient of 1.158 and is statistically significant. Model (1) does not include the RPI variable and is included in table 1 for comparison purposes. We also ran a t-test and an F-test in order to verify that our RPI variable significantly contributed to the model. The adjusted-R increased from .078 to .106.

The Relative Price Index seems to suggest that there was in fact a substitution effect between food and manufactured goods that contributed to changes in consumption patterns. Another difference between model (1) and (2) is that we replaced the born in Midwest variable with two other variables: born and enlisted in New York and born and Enlisted in Pennsylvania. We can see again that there is an advantage to being born and raised in the Midwest. However, we have additional insight that there was an advantage to being born in New York over Philadelphia. Both of these variables are statistically significant.

Table 2: Parameter Values

| **Parameter** | **1** | **2** |
|---|---|---|
| Relative Price Index (RPI) | | 1.158 |
| | | (2.153)* |
| Farmer | .415 | .268 |
| | (.502) | (1.26) |
| Professional1 | .421 | -.383 |
| | (.488) | (-.773) |
| Professional2 | -.244 | -.432 |
| | (-.290) | (-1.231) |
| Artisan | -.018 | -.581 |
| | (-.022) | (-2.318) |
| Service | -.129 | -.414 |
| | (-.153) | (-1.184) |
| Manual | -.036 | |
| | (-.044) | |
| Unproductive | .163 | |
| | (.185) | |
| Agricultural Worker | -.553 | 2.949 |
| | (-.359) | (1.066) |
| Born in Midwest | .561 | |
| | (7.839)* | |
| NY resident | | -1.542 |
| | | (-5.980) |
| PA resident | | -.78 |
| | | (-2.081) |
| Born 1826-1830 | 1.803 | 1.836 |
| | (11.399)* | (5.668)* |
| Born 1831-1835 | 1.569 | 1.808 |
| | (13.629)* | (7.564)* |
| Born 1836-1843 | 1.314 | 4.481 |
| | (17.364)* | (9.642)* |
| Intercept | 66.349 | 66.264 |
| | (80.224)* | (132.959)* |
| Adj-R2 | .078 | .106 |
| N | 5560 | 1751 |

# 6 Conclusion

The Antebellum Puzzle refers to the empirical evidence that the average height of the American population was declining during a time of significant economic growth. Research regarding the antebellum puzzle has given various explanations for declining heights and increasing mortality rates during the first half of the nineteenth century. We analyze an additional explanation. The purpose of this paper is to determine if there was a substitution effect between food and manufactured goods that may have had a deleterious effect on ones height during the antebellum period. We constructed a variable that reflects the relative prices of food and manufactured goods. Our model seems to verify that there was in fact a substitution away from food and towards manufactured goods that impeded Americans heights during the antebellum period.

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